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PREFACE

Direction finding (DF) involves determining the direction of arrival of a radio wave. Since the conception of signals intelligence (SIGINT) gathering, direction finding has been an important part of the intelligence cycle. Direction finding is used to support other intelligence information. It is normally integrated with other sources of intelligence such as communications and noncommunications intercept to determine the approximate location, movement, and relocation of threat emitters. Direction finding bearings and locations are used in developing threat order of battle (OB) information to support national and tactical intelligence information.

This field manual provides direction finding doctrine, procedures, techniques, and theory for personnel conducting strategic and tactical operations. It is written for military intelligence (MI) organizations; supported commanders and their staffs; echelons above corps (EAC) conducting direction finding operations; strategic joint operations personnel needing direction finding information; intelligence analysts; and direction finding supervisors, operators, and analysts.

The subject area of *strategic systems* refers to DF systems at a permanently fixed or semifixed site that have long-range DF capability. The area of *tactical systems* refers to semipermanent or mobile DF systems on the battlefield. These systems have a short- to medium-range DF capability.

The words *target* or *target area* are used for the purpose of brevity. These terms are synonymous with *target transmitting antenna*. The transmitting antenna may be far removed from the actual location of the transmitter.

The proponent of this publication is Headquarters, United States Army Training and Doctrine Command (TRADOC). Send comments and recommendations on DA Form 2028 directly to the Commander, United States Army Intelligence School, Fort Devens (USAISD), ATTN: ATSI-ETD-PD, Fort Devens, Massachusetts 01433-6301.

Unless this publication states otherwise, masculine nouns and pronouns do not refer exclusively to men.

FIELD MANUAL
NO 34-40-9

HEADQUARTERS
DEPARTMENT OF THE ARMY
Washington, DC, 29 August 1991

DIRECTION FINDING OPERATIONS

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CHAPTER 1

ELEMENTS

Direction finding involves determining the direction of arrival of a radio wave. Direction finding equipment will indicate the approximate direction along an imaginary line on which a transmitting antenna lies. This is commonly referred to as a line of bearing (LOB). The information obtained by a single direction finding site is seldom accurate enough to pinpoint a location. However, the direction of a distant transmitter's antenna can be determined (depending on the training and expertise of the DF personnel and the DF equipment used) to an accuracy of plus or minus 2 degrees. With the exception of the single station locator (SSL), one DF site can only indicate the approximate direction of a transmitter's antenna (Figure 1-1).

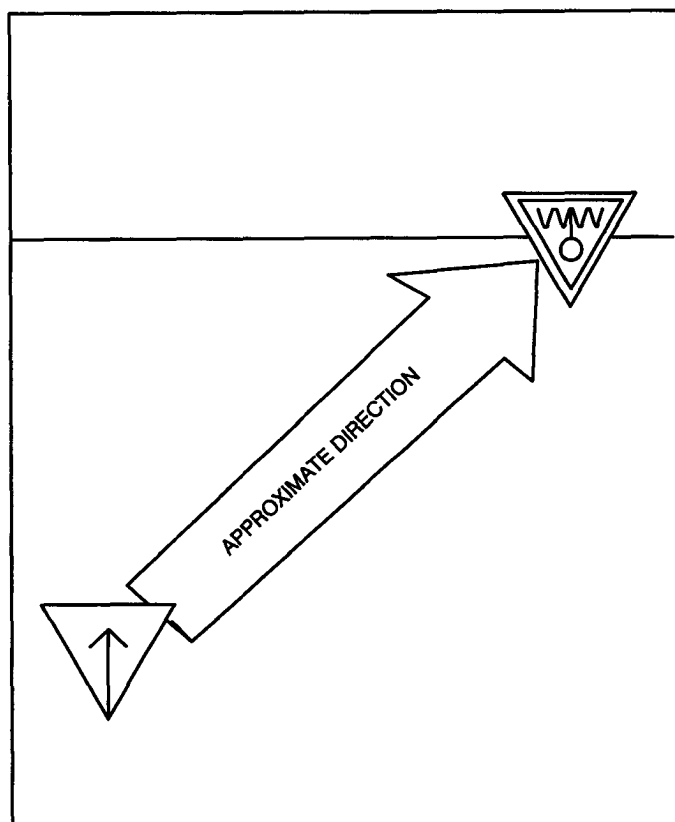


Figure 1-1. LOB of a distant transmitter's antenna.

Two DF sites, however, can indicate the general location of a transmitter's antenna by providing a *cut* (Figure 1-2).

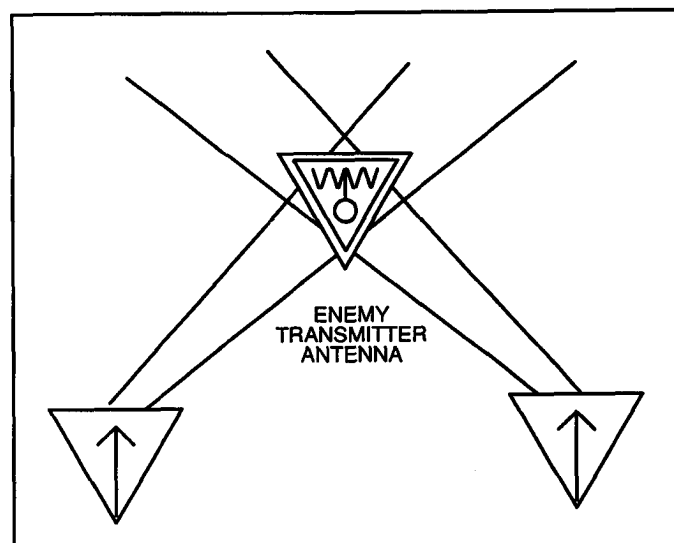


Figure 1-2. General location of a distant transmitter's antenna (cut).

Three or more DF sites can provide the fix location of a desired transmitter's antenna (Figure 1-3).

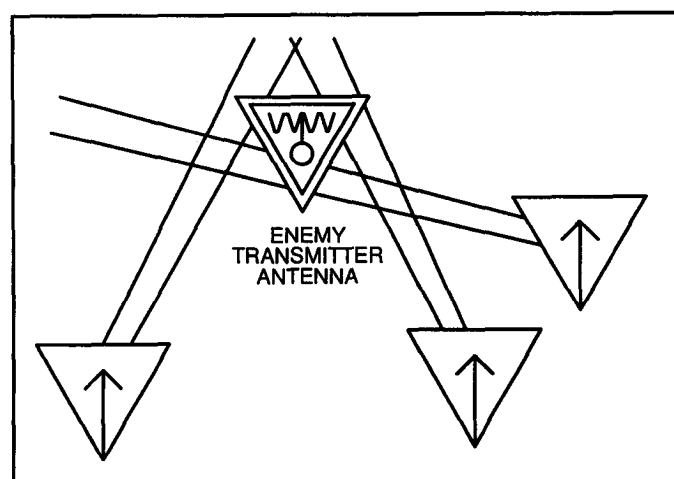


Figure 1-3. Fix location of a distant transmitter's antenna.

The theory of direction finding has remained reasonably static since the early history of the study of electromagnetic (EM) wave phenomena. Early radio communications were directional in nature. This was because the radio transmitters were relatively low powered. They were inefficient in their output, and the receivers were relatively insensitive. Efforts were undertaken to *direct* the transmitted wave toward the receiving device. This was done to ensure communications rather than to determine location. Therefore, the useful applications of DF were obtained almost simultaneously with the effort to direct the radio transmissions.

Direction finding has many uses. It can be used as a navigational aid. In this capacity, the DF equipment is either used alone or in combination with other DF systems. This depends on the service which is to be provided. Such service includes positioning, controlling, and homing of ground, sea, and air forces. DF equipment is also used by rescue personnel as an essential part of air-sea rescue. Also, crash beacons on

downed aircraft or disabled ships provide a signal which can be located (or *homed-in* on) by DF equipment.

The extensive use of military radio communications has increased the value of DF in the production of SIGINT. Even if a military force is extremely careful, radio and radar transmissions can be intercepted and the locations of the transmitter's antennas determined. Direction finding can provide enemy transmitter antenna locations to intelligence personnel for the construction of enemy order of battle and fusion into other intelligence activities. Specifically, direction finding can also be used to assist in determining—

- Enemy troops or equipment movements which may indicate a possible attack.
- Locations of transmitting antennas associated with various weapon systems (to help determine enemy capabilities).
- New, and confirming known, transmitter antenna locations.
- Possible targets for jamming or intercept.

CHAPTER 2

RADIO WAVE PROPAGATION

Radio direction finding (RDF) deals with the direction of arrival of radio waves. Therefore, it is necessary to understand the basic principles involved in the

propagation of radio waves from the transmitting station to the DF equipment.

CHARACTERISTICS

The distance between two points of corresponding phase in consecutive cycles is known as a wavelength. A wavelength can be expressed in any unit of measure. However, it is normally expressed in meters. The number of complete waves that move past a given point in one second is called frequency. A unit of frequency is called Hertz (Hz). One unit is equal to one cycle per second (Figure 2-1). The radio wave's strength or

intensity is called its amplitude. The radio wave, which is electromagnetic in nature, consists of an electrical field (E field) and a magnetic field (H field). Each field supports the other, and neither can be propagated by itself. Table 2-1, page 2-2, lists frequency bands, their designators, and the commonly accepted limits of each band.

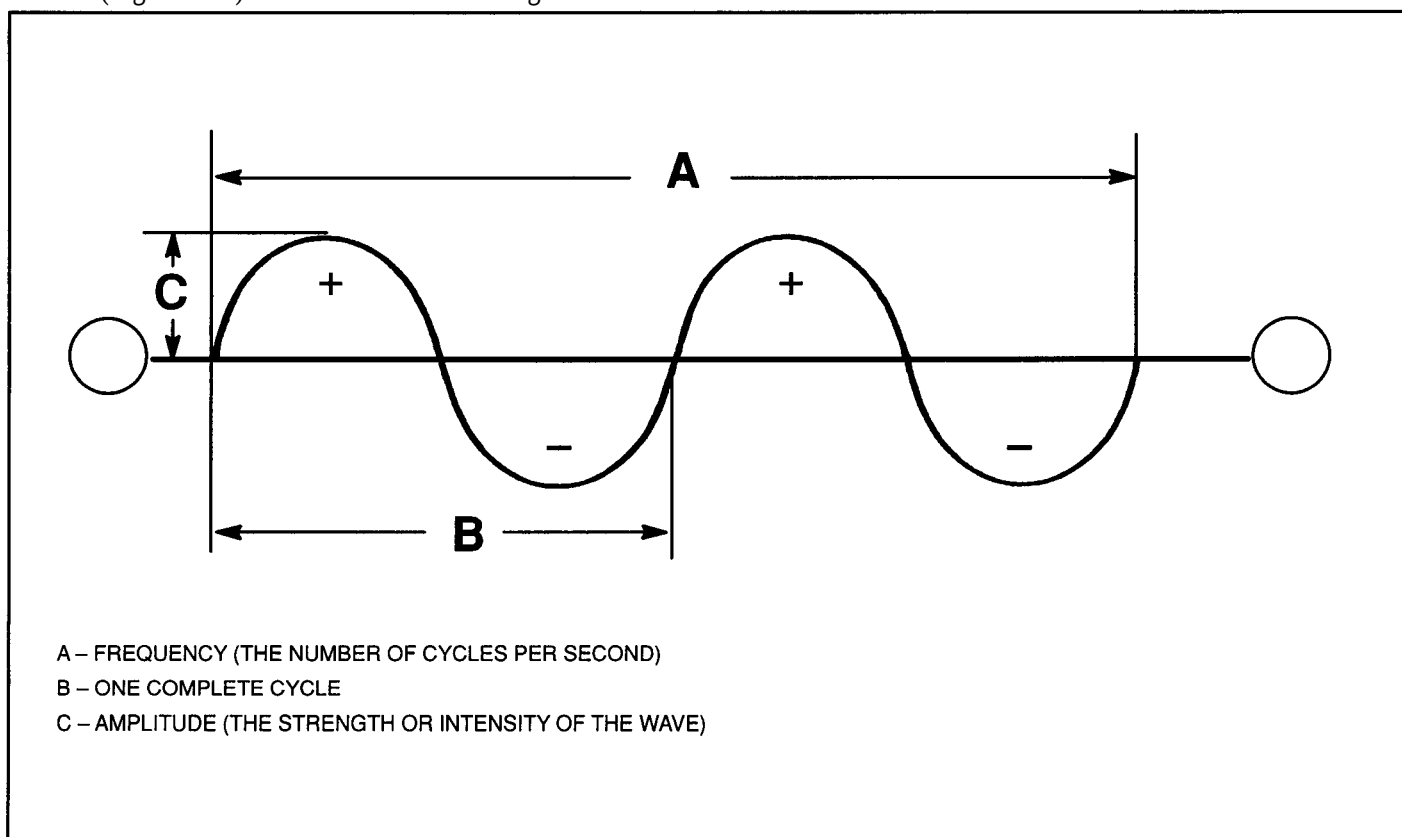


Figure 2-1. Wavelength characteristics.

Table 2-1. Frequency range and band designator.

FREQUENCY RANGE		BAND DESIGNATOR
3-30	kilohertz (kHz)	very low frequency (VLF)
30-300	kHz	low frequency (LF)
300-3000	kHz	medium frequency (MF)
3-30	megahertz (MHz)	high frequency (HF)
30-300	MHz	very high frequency (VHF)
300-3000	MHz	ultra high frequency (UHF)
3-30	gigahertz (GHz)	super high frequency (SHF)
30-300	GHz	extremely high frequency (EHF)

POLARIZATION

The direction of the E field of a radio wave, relative to the ground, determines the polarization of the wave. Polarization can either be horizontal, vertical, or a mutation which adopts portions of vertical and horizontal. The latter results in a circular or a hybrid form of a wave. If a whip or other vertical type transmitting antenna is used to propagate radio waves, the transmitted wave is considered to be vertically polarized. If the transmitting antenna is horizontal, relative to the earth's surface, the transmitted wave is horizontally polarized.

To illustrate vertical wave polarization, imagine a rope lying reasonably straight on the ground. One end is attached to a tree or other support (Figure 2-2). If the loose end of the rope is raised, tightened, and given a violent up and down motion, a series of undulating waves will travel along the rope. The movement of the waves will be vertical to the earth and clearly visible.

If the same rope had a similar movement applied in a horizontal manner, the waves would be in a horizontal plane. These waves would be called horizontally polarized (Figure 2-3).

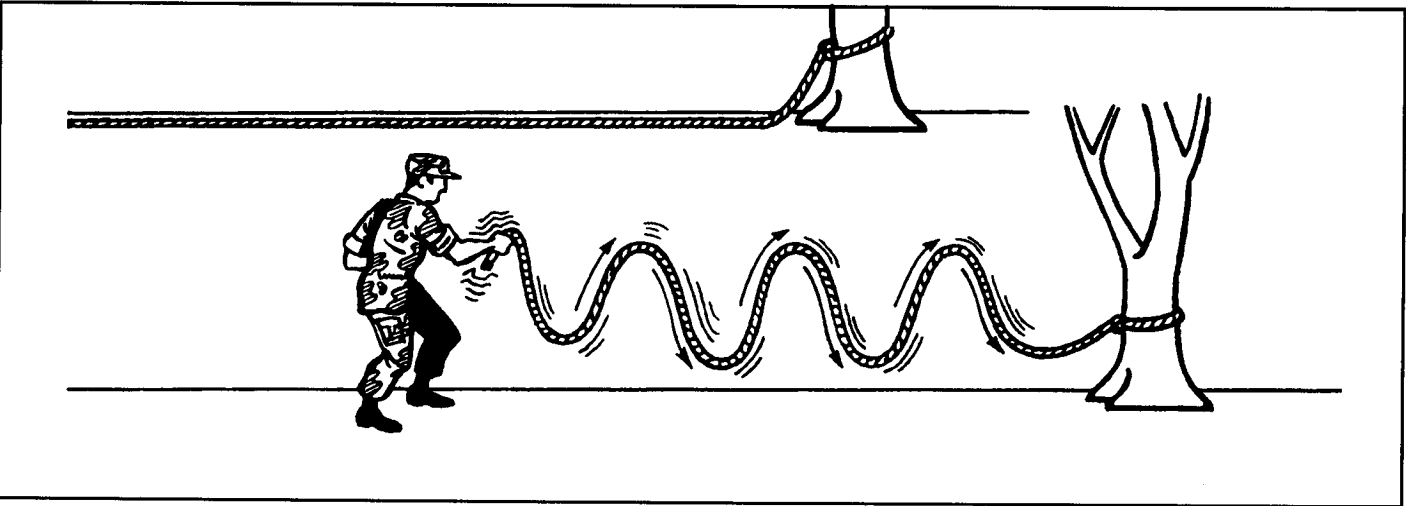


Figure 2-2. Vertical wave polarization.

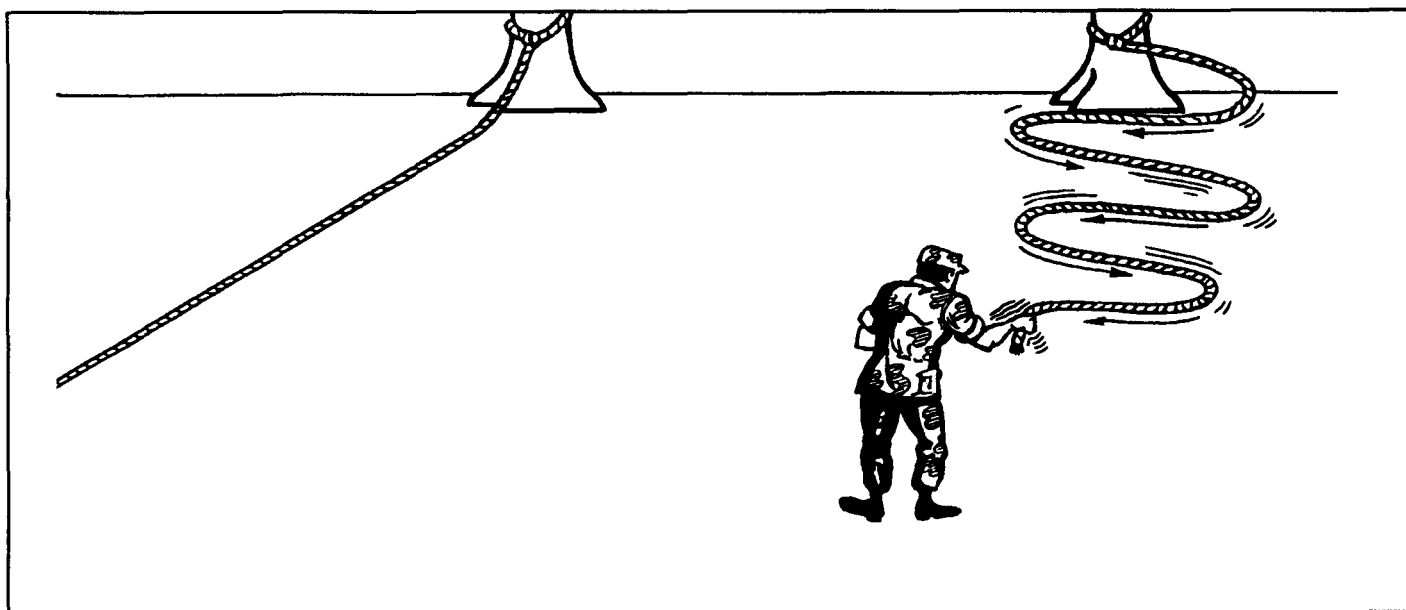


Figure 2-3. Horizontal wave polarization.

PROPAGATION FACTORS

Radio waves are electromagnetic waves which travel through space at the same speed as light. They travel approximately 186,000 miles per second or 300,000,000 meters per second. A conversion formula for wavelength and frequency is shown below. If the measurement in Hertz is known and a conversion to wavelength is desired, apply—

$$\text{Wavelength (meters)} = \frac{300,000,000}{\text{Frequency (Hz)}}$$

If wavelength (in meters) is known and a conversion to frequency (Hz) is desired, apply—

$$\text{Frequency (Hz)} = \frac{300,000,000}{\text{Wavelength (meters)}}$$

Radio wave propagation is defined as extending or transmitting electromagnetic energy through space. Wavelength, frequency, and polarization are all essential elements of the actual wave and are factors which affect the radio wave propagation. The simplest form of propagation is through the space wave. The wave is radiated from the transmitter and continues through

space in a line of sight (LOS) fashion until it reaches the receiver. Over a flat surface there are few problems in interception or direction finding. However, we do not live on a flat surface. The curved surface of the earth, while appearing to be flat over a short distance, limits the effective LOS range.

Radio waves tend to travel in straight lines unless they are acted on by some force. They can be reflected off the surface of any sharply defined object such as the earth's surface. The radio waves can also meet other obstructions or objects that will scatter or reflect the signal. They can be reflected, refracted, or diffracted. Factors which affect radio wave propagation include—

- Wavelength.
- Polarization.
- Space (or the medium through which waves travel).
- Physical obstructions.

All of the above factors contribute to or create additional considerations. Personnel engaged in or using direction finding results must understand these factors.

Reflection

When observing oneself in a mirror, the light beams or waves reflected directly off the mirror's silver finish give the identical or mirror image, barring an optical distortion. Radio waves are reflected similar to light waves traveling at the same speed. Although light waves can be seen, radio waves must be detected by electronic equipment. Figure 2-4 illustrates how radio waves are reflected off the ionosphere. The reflective components of light beams are further illustrated in Figure 2-5.

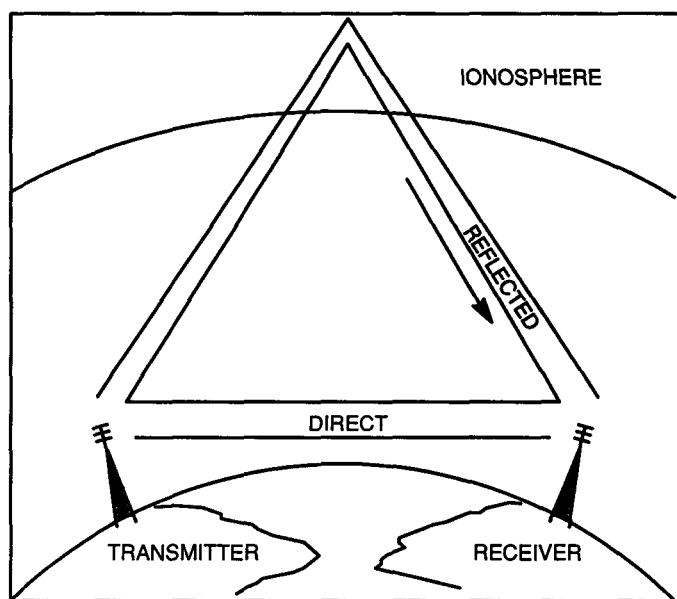


Figure 2-4. Reflected radio waves.

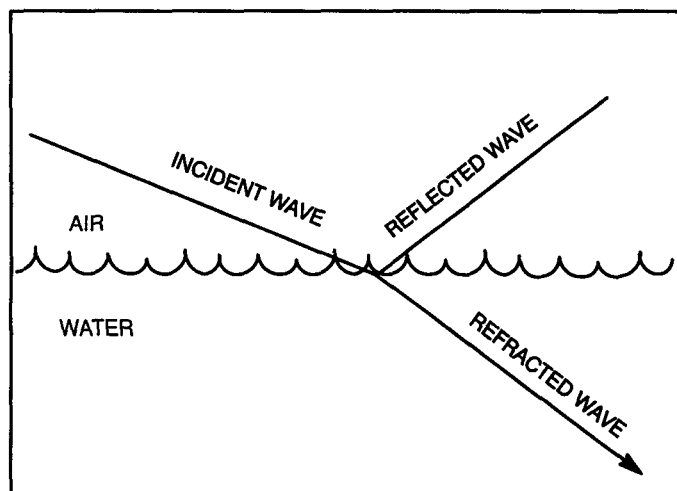


Figure 2-5. Reflection of a light beam.

Refraction

Refraction can best be illustrated by a pencil held obliquely so that a portion of it is beneath the surface of some water (Figure 2-6). From most viewpoints, the pencil will have the appearance of being bent at the point where it enters the water. This effect is because light waves travel more slowly in water than in air. This causes a change in direction of travel of the refracted light. Also, radio waves travel at a different speed over water than land. Therefore, when passing from land to water or vice versa, the radio wave is refracted or bent. Note, refraction occurs only when the wave or light beam approaches the new medium at an oblique angle. If the whole wave front arrives at the new medium at the same moment (perpendicularly), it is slowed uniformly and no bending occurs.

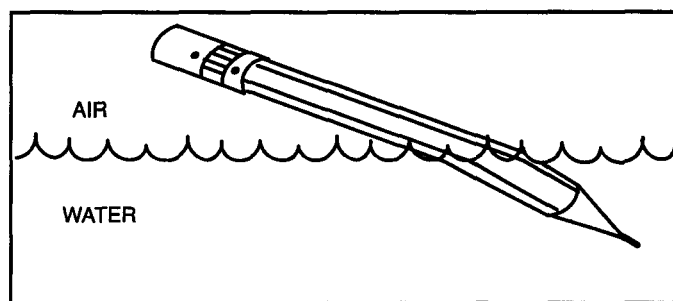


Figure 2-6. Refraction of a pencil.

Diffraction

Diffraction of a radio wave is the phenomena of bending the wave around a solid object. The lower the frequency or the longer the wavelength, the greater the bending of the wave. Therefore, radio waves are more readily diffracted than light waves. Sound waves are more readily diffracted than radio waves. Figure 2-7 illustrates why radio waves of the proper frequency can be received on the far side of a hill or other natural obstruction. It also illustrates why sound waves can be heard readily around the corner of a large building. Diffraction is an important consideration in the propagation of radio waves over long distances. The largest object to contend with is the curvature of the earth. It prevents the direct passage of the waves from the transmitter to the DF receiver.

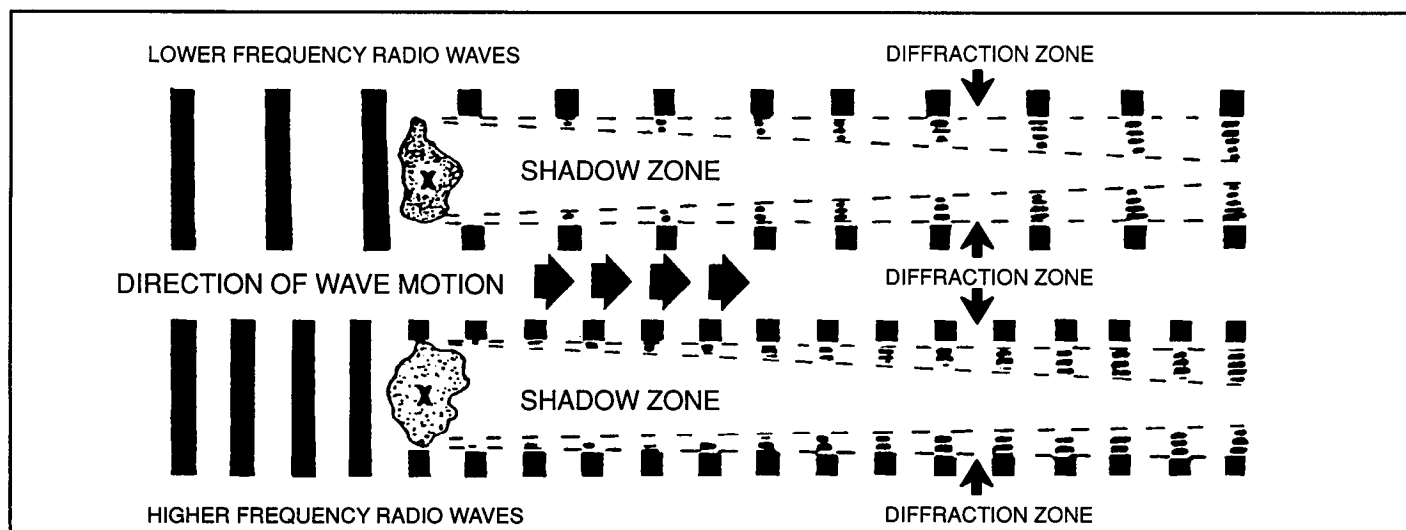


Figure 2-7. Diffraction of radio waves around a solid object.

ATMOSPHERE

The earth's atmosphere plays a crucial role in long distance radio communications. Radio waves may be reflected in the atmosphere and returned to earth. This technique is discussed later in this chapter. As shown in

Table 2-2, the atmosphere consists of multiple layers, of which only a few have any discernible effect on radio waves. The ionosphere is the primary layer that is used to return a radio wave back to earth.

Table 2-2. Characteristics of the atmosphere.

ATMOSPHERIC REGION	LOCATION (Km)	FEATURES	EFFECT ON COMMUNICATIONS (Radio Frequency)
Ionosphere	Extending 50-600 km from the earth's surface.	Electrically charged set of layers, with large amounts of free electrons.	Excellent reflection/refraction of MF and HF signals. Some VHF may be propagated as well. Primary medium for sky wave communications.
Stratosphere	Extending 15-50 km from the earth's surface.	The only isothermal region of the atmosphere.	No effect.
Troposphere	From earth's surface to 10-15 km.	Lowest region of the atmosphere. Sustains life. Temperature decreases with increasing altitude.	Negligible effect. Allows direct, surface, and ground wave communications of all frequencies.

Ionosphere

The ionosphere is a region of ionized (electrically charged) gasses located approximately 50-600 kilometers (km) above the earth’s surface. As illustrated in Table 2-3, there are essentially four layers (D, E, F1, and F2) of the ionosphere which affect communications and DF. These layers vary in ionization and height above the earth’s surface, depending on the amount of exposure to the sun.

The ionosphere is formed when extreme ultraviolet light from the sun strips the electrons from neutral atoms in the ionosphere. Thus, the electrons become *free* (unbound), and the remaining atom becomes positively ionized. The free electrons reflect/refract radio waves of a certain frequency. Due to this process, the E and F layers become positively ionized.

However, the free electrons may attach to neutral atoms. When such attachments occur, the atoms become nega-

tively ionized. This process is common in the D layer, making the region of the ionosphere negatively ionized.

Factors which influence the ionosphere and its effect on radio waves include—

- The time of day.
- The seasons of the year.
- Solar flares.
- Magnetic storms.
- Certain man-made disturbances such as nuclear detonations.

An important relationship between radio waves and the ionosphere is that the higher the frequency, the less its tendency to bend. Depending upon ionospheric conditions and the angle of the signal’s arrival at the ionosphere, the bending may be slight. The radio waves may not be sent back to earth (Figure 2-8).

Table 2-3. Characteristics of the ionosphere.

IONOSPHERIC LAYERS	LOCATION (Km)	FEATURES	EFFECT ON COMMUNICATIONS (Radio Frequency)
D	50-100 km	Layer closest to earth. Negatively ionized layer, with relatively little free electrons. Exists during the day.	Primarily acts to absorb radio waves. Small amounts of refraction are possible, but unpredictable.
E	100-200 km	Positively ionized with varying amounts of free electrons. State changes with temperature, angle of the sun, magnetic fields, and time of day. Exists during the day.	Erratic behavior. Sometimes reflects/refracts radio waves in MF, HF, and lower VHF bands.
F	145-400 km (F1–145-200 km) (F2–240-400 km)	Very positively ionized with large amounts of free electrons. During the day, this region separates into the F1 and F2 layers. The F region decreases in ionization and increases in altitude at night.	Primary means of reflecting/refracting MF and HF signals in sky wave propagation. At night, behavior becomes slightly erratic, but communications distances are much greater.

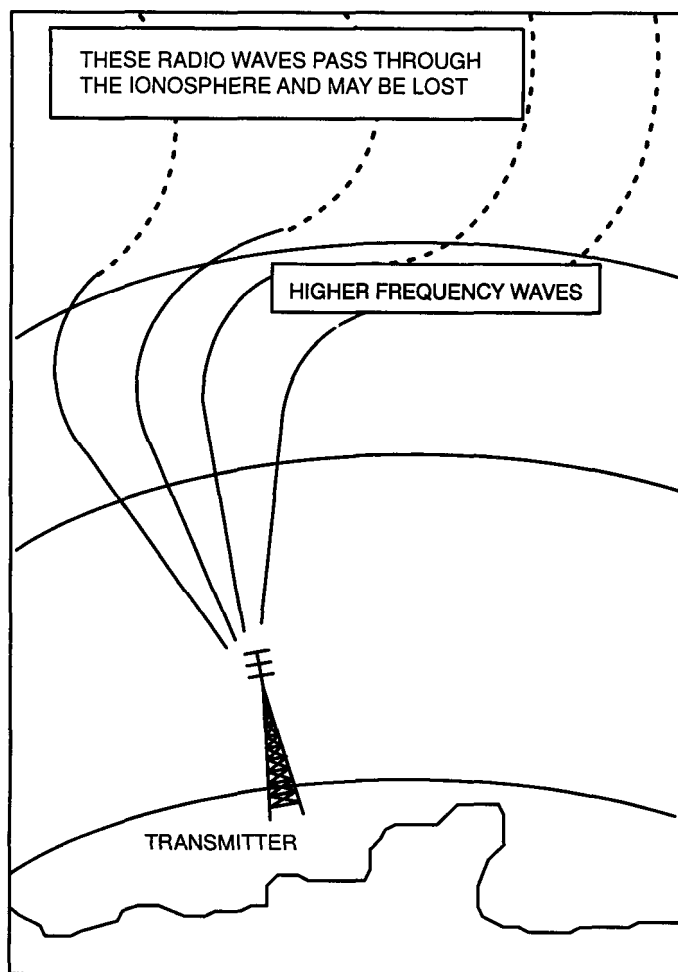


Figure 2-8. High frequency wave penetration.

During daylight hours, the ionosphere is subject to full ultraviolet output from the sun. Therefore, the D, E, F₁, and F₂ layers reach their full potential. At night, the composition of the layers of the ionosphere changes as the F layers combine. Therefore, higher radio frequencies are more likely to penetrate the ionosphere and be lost. As a general rule, lower communication frequencies are used during the night.

Conversely, during the day when ionization of the atmosphere is more intense, higher communications frequencies can be used without undue loss of the signal. This is because penetration of the ionized layer is at a minimum. Changes in the relative proximity of the sun to the earth will also cause gradual changes in the ionosphere. The longer exposure of the ionosphere to the sun in the summer causes a greater degree of ionization during the night and day. Therefore, higher

frequencies may be used for summer operations. Figure 2-9 illustrates the approximate heights of the various layers of the ionosphere.

Remember, however, that the actual number of layers, their heights above the earth, and the relative intensity of ionization present will vary. They vary from hour to hour, from day to day, from month to month, and from year to year.

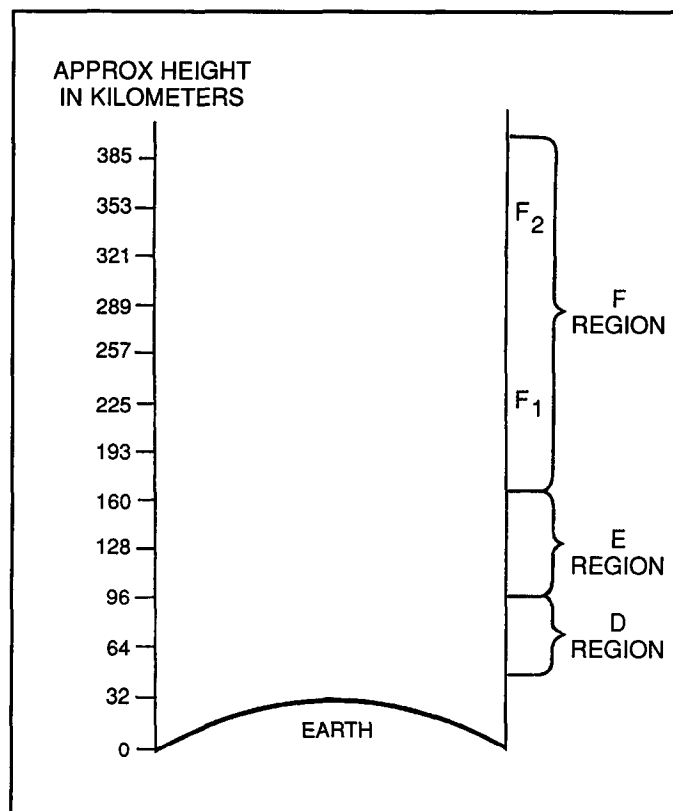


Figure 2-9. Approximate heights of ionospheric layers.

Stratosphere

The stratosphere is that portion of the earth's atmosphere between the ionosphere and the troposphere. Since the temperature in this region is considered to be almost constant, it is also known as the isothermal region. The stratosphere has little, if any, effect on radio waves which are transmitted through it. It is mentioned only to differentiate the three major regions of the earth's atmosphere.

Troposphere

The troposphere greatly influences electromagnetic emissions. It is that portion of the earth's atmosphere extending from the surface of the earth to heights of

approximately 10 to 15 kilometers. This region contains the mixture of gasses we depend on for life. Additionally, most weather activity occurs in the troposphere.

WAVE PATHS

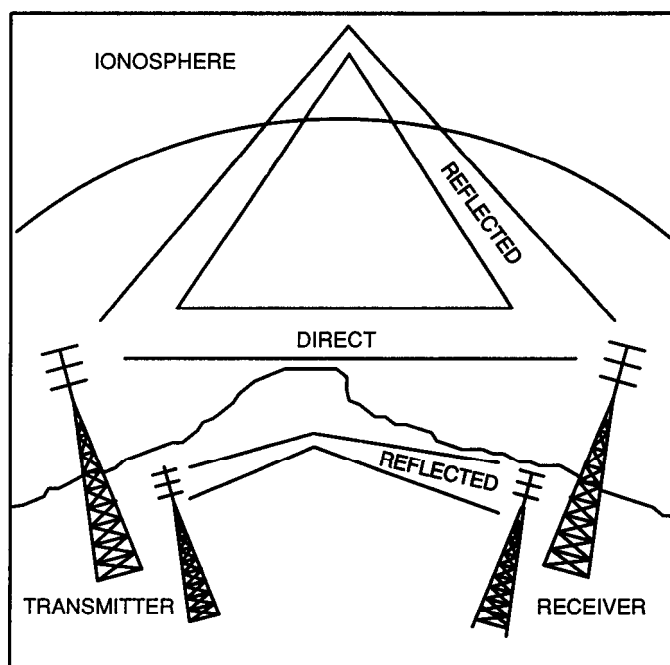
There are three distinct paths that a radio wave may take to reach the receiving antenna. They are—

- Direct.
- Reflected.
- Refracted.

The direct and reflected paths are shown in Figure 2-10. They are purposely exaggerated to enable the reader to clearly grasp the differences.

The direct path goes directly from the transmitting to the receiving antenna. The reflected path bounces off the ionosphere or the surface of the earth at the same angle at which it arrives and continues to the receiving antenna (angle of incidence = angle of arrival). The refracted path is the path caused by the bending of the waves in the same manner light waves are bent when seen through water.

If the waves are refracted by the earth, the distance they travel is severely limited due to large losses of energy in the form of heat dissipated into the earth's crust.



WAVE TYPES

Radio waves may be classified as either ground waves or sky waves (Figure 2-11).

Ground waves are continually in contact with the earth's surface. They do not make use of reflection from the ionosphere. They have a tendency to be refracted and, in some cases, reflected into the lower atmosphere. At frequencies above 1500 kilohertz, a ground wave is affected very little by the time of day or season. The ground wave loses much of its strength and dissipates energy as it travels over the earth's surface. However, less strength is lost when it travels over water.

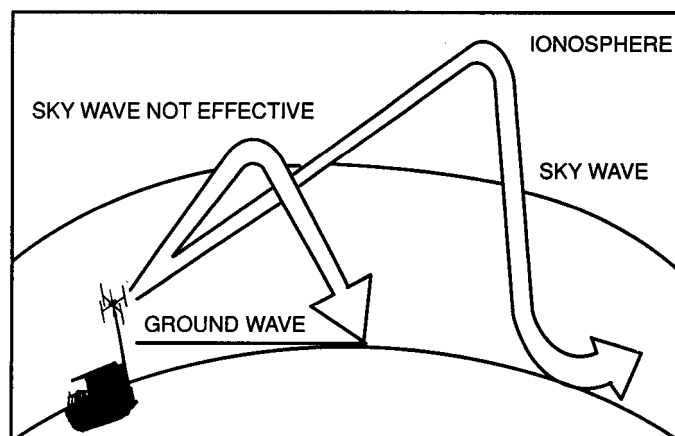


Figure 2-11. Ground waves and sky waves.

Sky waves are transmitted upward with respect to the earth's surface. Sky waves would not be useful for communications were it not for the ionosphere. Radio waves approaching the ionosphere at an angle are refracted back to earth. They may be detected and used

for communications purposes or for DF exploitation. Figure 2-12 depicts the waves that penetrate the ionosphere and are lost for all practical purposes. It also illustrates those waves that return to earth for communication use.

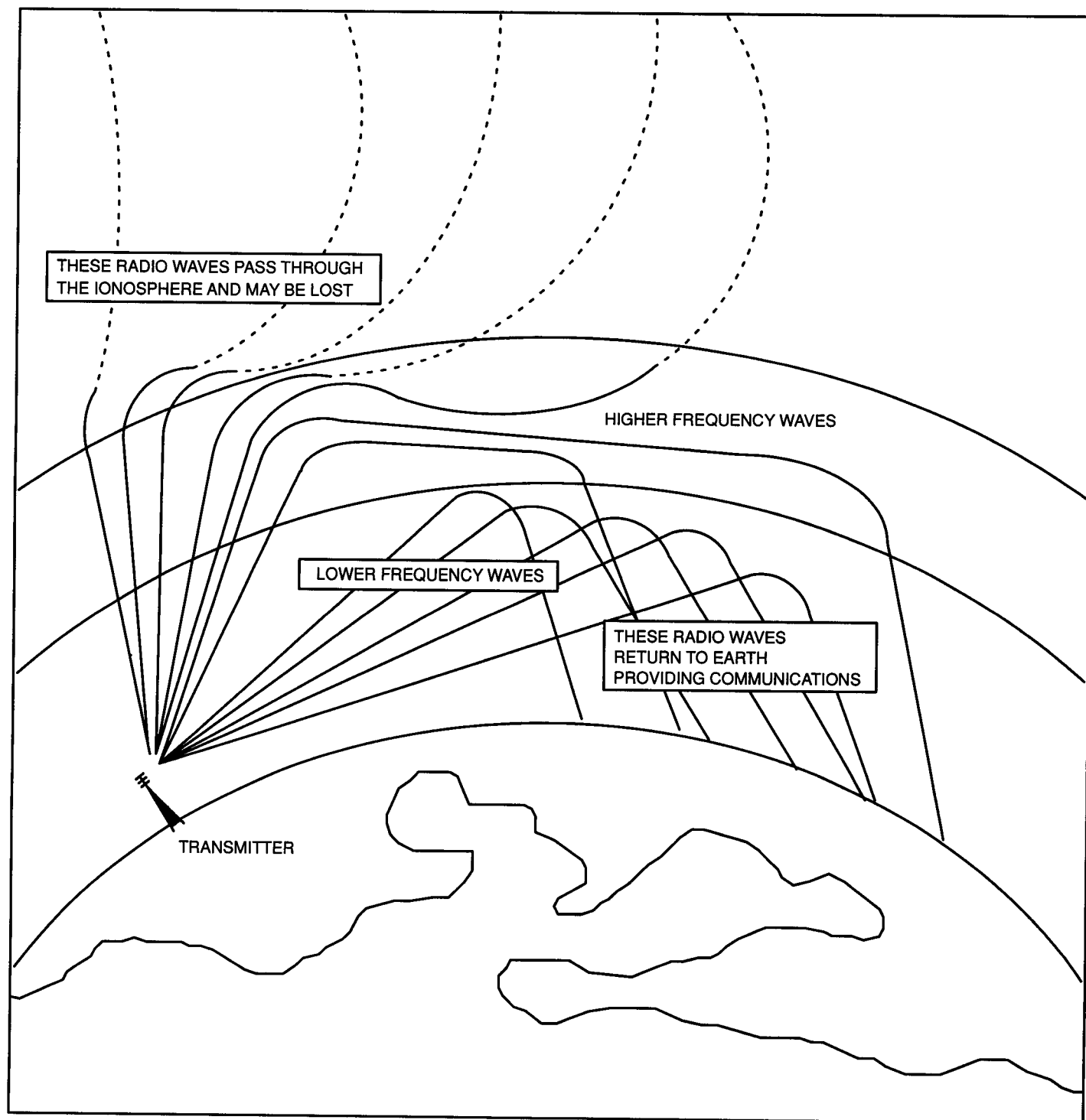


Figure 2-12. Sky waves.

SKIP ZONE AND DISTANCE

The skip zone is the area where the ground wave can no longer be detected (Figure 2-13) and the sky wave has not yet returned to earth after being reflected or refracted off the ionosphere or troposphere. The skip distance is that area where no sky wave reception will be possible. This is because the wave has not returned to earth after its first or subsequent bounce off the reflecting layer.

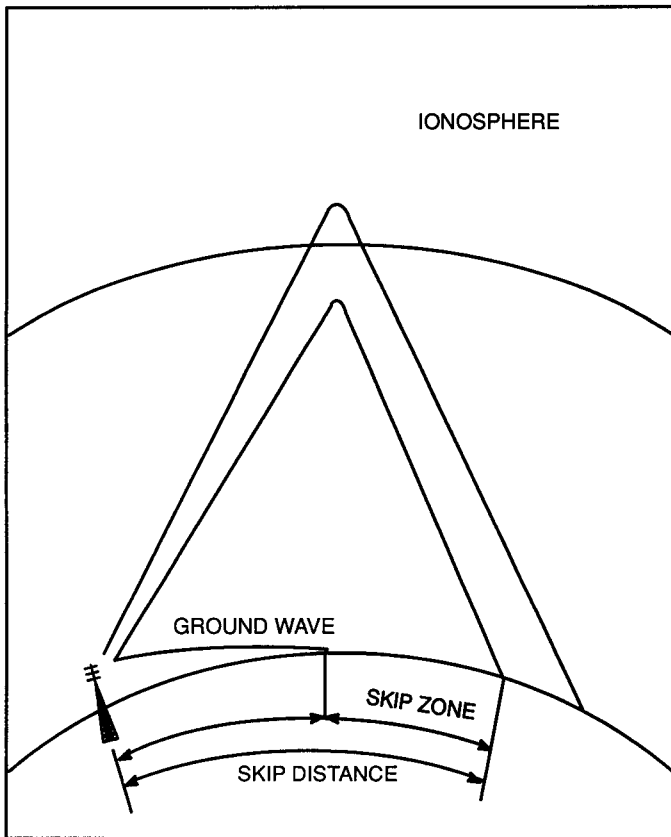


Figure 2-13. Skip zone and distance.

Depending upon the frequency and the transmitter power, multihop transmissions are routinely used for communications. Figure 2-14 illustrates multihop transmissions. There will be, however, skip zones between the points of the wave's return at each hop. Note, however, skip zones are not static or stable.

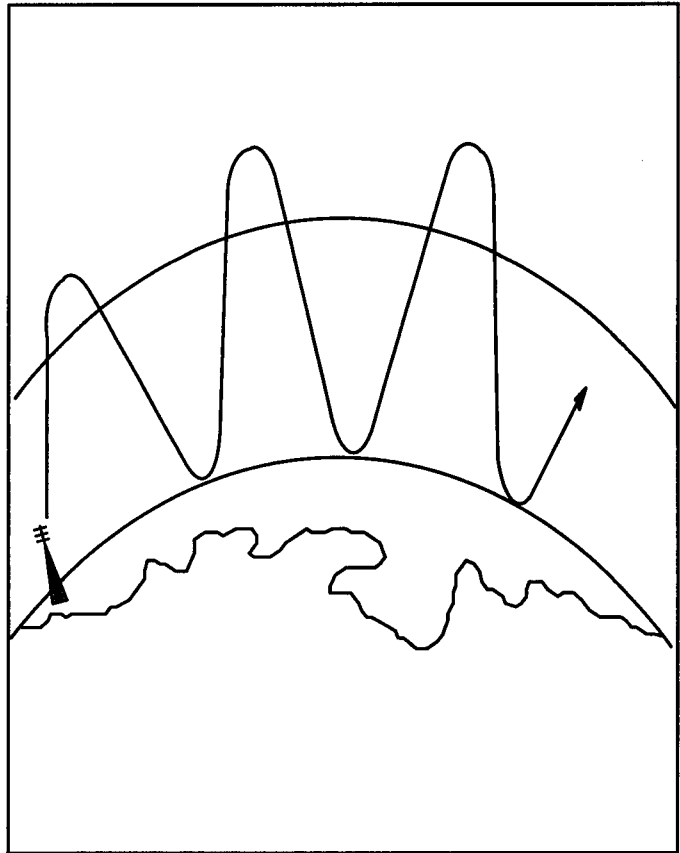


Figure 2-14. Multihop transmissions.

CHAPTER 3

TECHNOLOGY

The Army has several DF systems that target varying types of threat signals, frequencies, and ranges. The DF systems are also characterized by their mobility and their assigned military echelon. These systems are outlined in Table 3-1.

This chapter relates some of the historical and technological developments in acquiring a signal

azimuth. It explains some of the antennas, systems, and bearing indicators used to obtain DF information. All direction finding systems serve one primary purpose-to measure the angle of arrival of an EM wave in reference to a known reference (true, magnetic, or grid north).

Table 3-1. Army direction finding systems.

EQUIPMENT	ECHELON	MOBILITY	SIGNALS	MOS (Op/Maint)	FREQ (DF)
AN/PRD-10 MRDFS	Div, ACR MI Co (SF)	Ground Vehicle Manpack	CW, AM, FM, SSB	98G/33T	VHF
AN/PRD-11 MANPACK	Div, ACR MI Co (SF)	Ground Vehicle Manpack	CW, AM, FM, SSB	98G/33T	VHF, UHF
AN/TRQ-32 TEAMMATE	Corps, Div ACR	Ground Vehicle	CW, AM, FM, SSB	98G, 98H, 33T	VHF
AN/TRQ-37 TACFIX	Div	Ground Vehicle	CW, AM, FM, SSB	98G, 98H, 33T	VHF
AN/TSQ-138 TRAILBLAZER	Div	Ground Vehicle	CW, AM, FM, SSB	98G/33T	VHF
AN/TRD-15/23	EAC	Ground Vehicle Semi-Fixed	CW, AM, FM, SSB	98D/33T	HF
AN/TSQ-152 TRACKWOLF	EAC	Ground Vehicle Semi-Fixed	CW, AM, FM, SSB	98D, 98H, 98G/33T	HF
AN/FLR1-9	EAC	Fixed	CW, AM, FM, SSB	98D/33P	HF
DF-6	EAC	Fixed	CW, AM, FM, SSB	98D/33P	HF
AN/ALQ-151 QUICKFIX	Div, ACR	Airborne	CW, AM, FM, SSB	98G/33R	HF, VHF
AN/USD-9 GUARDRAIL V	Corps	Airborne	CW, AM, FM, SSB	98D, 98C, 98G/33R	HF, VHF, UHF
AN/ALQ-133 QUICKLOOK II	Classified	Airborne	CW, Pulse	98J, 33T	UHF
AN/TSQ-164 DRAGONFIX	Corps	Ground Vehicle	CW, AM, FM, SSB	98G, 98H, 33T	HF

HISTORY OF MAJOR DIRECTION FINDING SYSTEMS

Loop Antenna

Early direction finding technology required a movable directional loop antenna and a receiver. The arrival angle is measured by moving the antenna until a maximum or minimum signal strength is achieved. The simple loop antenna (Figure 3-1), or some derivative of it, can still be found today. One of the disadvantages of using this method is that the signal being measured is reduced, while noise from other directions is not. To overcome this problem, wave amplitude comparison (using two directional antennas with different orientations) was introduced.

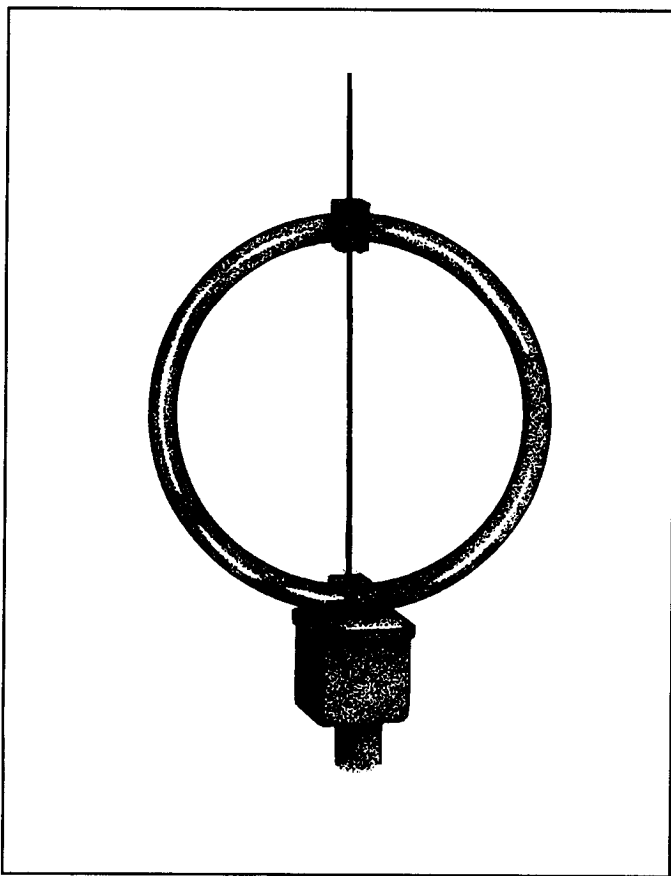


Figure 3-1. Loop antenna.

Rotating Loop

It was not always feasible or desirable to physically move the antenna. As a result, some RDF technology used a fixed antenna that measured signal strength to provide an azimuth. One of the earliest of these systems used fixed crossed loops to feed a small orthogonal loop arrangement with a rotating loop inside of it. This was called a goniometer. Today, the term goniometer may refer to any type of mechanical or electrical cyclic sampling equipment.

Cathode Ray Tube

The first cathode ray tube (CRT) direction finder used cross loops (Figure 3-2). Instead of using a goniometer, each loop was fed to a channel of a dual-channel receiver. The outputs from the receiver were applied to pairs of deflection plates within a special CRT.

A clear signal produced a straight line, the angle of which gives the azimuth of the signal.

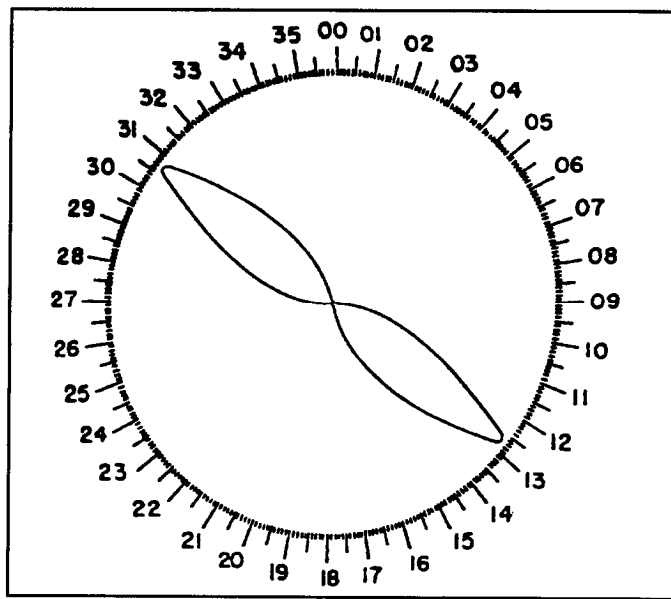


Figure 3-2. Cathode ray tube.

Adcock Antenna

Until the end of World War II (WWII), the most common type of DF system was the crossed loop or Adcock antenna (Figure 3-3). This antenna system is still used in modified form for short-distance direction finding systems. The Adcock antenna used top horizontal members that were well shielded, to reduce polarization errors. These systems were small in relation to the wavelength of the received signals. They were therefore classified as narrow aperture direction finding (NADF) systems.

Wullenweber System

During WWII, the Wullenweber system heralded the era of wide aperture direction finding (WADF) systems (Figure 3-4). The Wullenweber has a circularly disposed antenna array (CDAA) up to 1,000 meters in diameter with a large number of elements. About a third of the elements are combined to form sum/difference beams. The beams are effectively rotated in azimuth by a rotating switch (goniometer) which connects and combines elements around the ring.

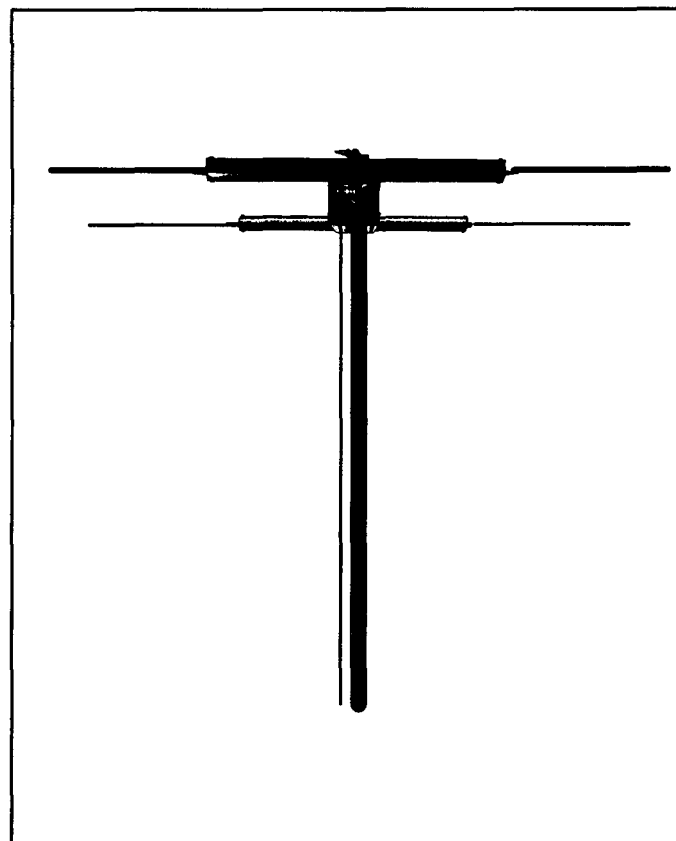


Figure 3-3. Adcock antenna.

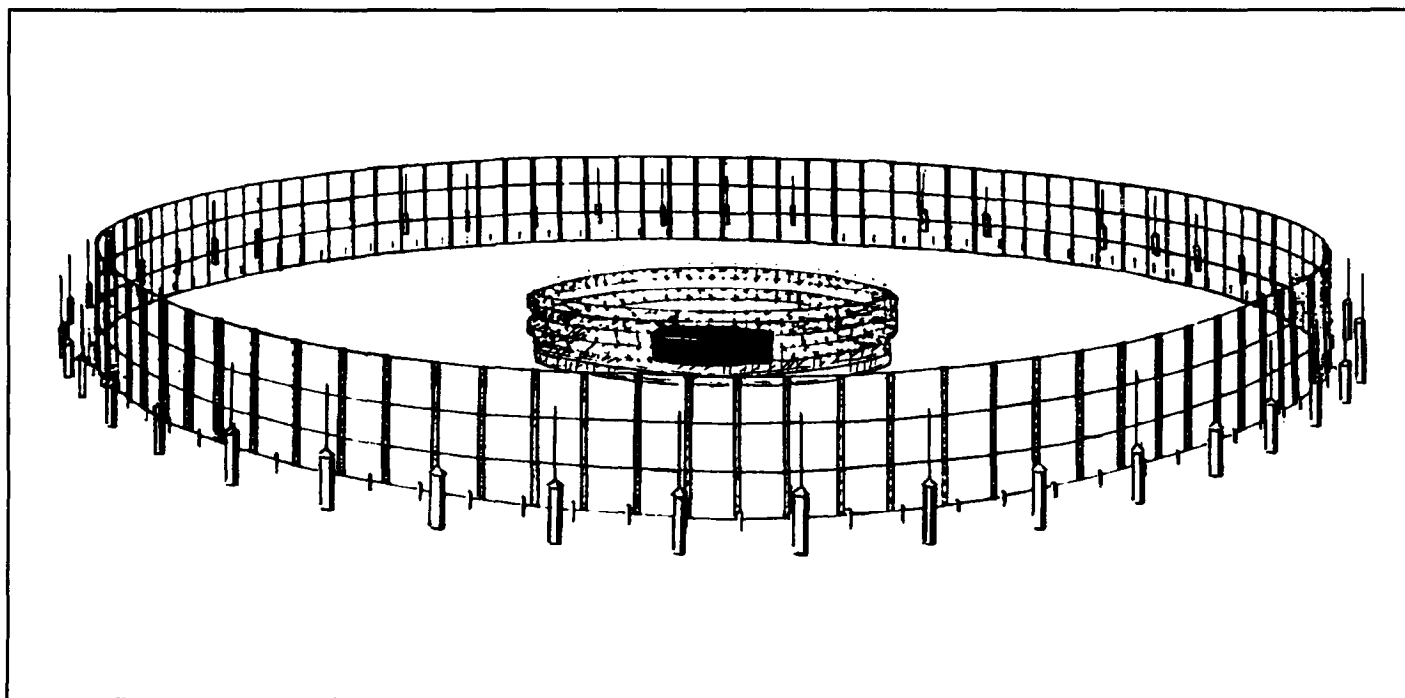


Figure 3-4. Wullenweber system.

Quasi-Doppler System

A further variation of the Wullenweber system is called the Quasi-Doppler or Pseudo-Doppler system (Figure 3-5). This variation has also been called a commutated-antenna direction finder (CADF). Most of the older groundbased EAC tactical direction finding

systems are of this type. In theory, the Doppler systems impose a phase modulation on the received signal by moving the antenna in a circle. The phase of the modulated signal is a function of its direction. In actual practice, a fixed CDAA is used. The receiver rapidly samples each antenna around the ring by using a goniometer switch.

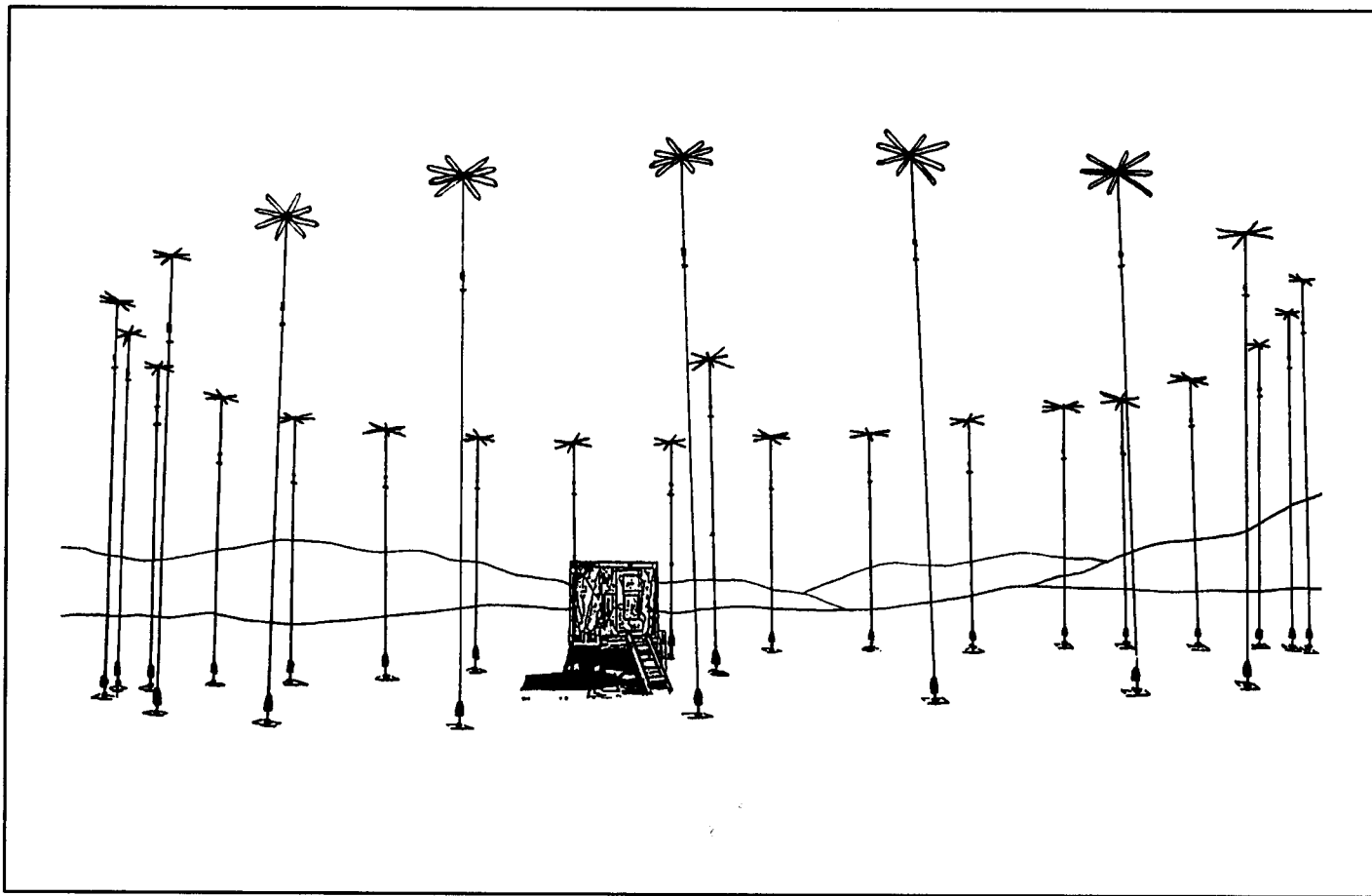


Figure 3-5. Quasi-Doppler system.

Interferometric System

Interferometric systems are a completely different class of direction finding systems (as illustrated in Figure 3-6). The azimuth of an incoming wave is not deduced by rotating beams. It is taken from the phase measurements of signals, made on a number of spaced antennas. Unlike the beam-forming type of WADFs, interferometers accept all signals on the array. Two different approaches are used to process the results. Depending on the type of system, one or both of the following may be used:

- Wavefront analysis (WFA).
- Wavefront testing (WFT).

Wavefront analysis accepts all signals but attempts to recover the major ones. It attempts this by analyzing the complex voltages measured on the elements of the antenna array under wave interference conditions.

Wavefront testing accepts only signals arriving from one direction or quasi uni-modal propagation (QUMP). QUMP is achieved by detecting a linear phase shift across the array with near equal amplitudes on all the elements. (This process is also called coincidence interferometry.) For further information on linear phase shift and measuring wave amplitude, see TM 11-666.

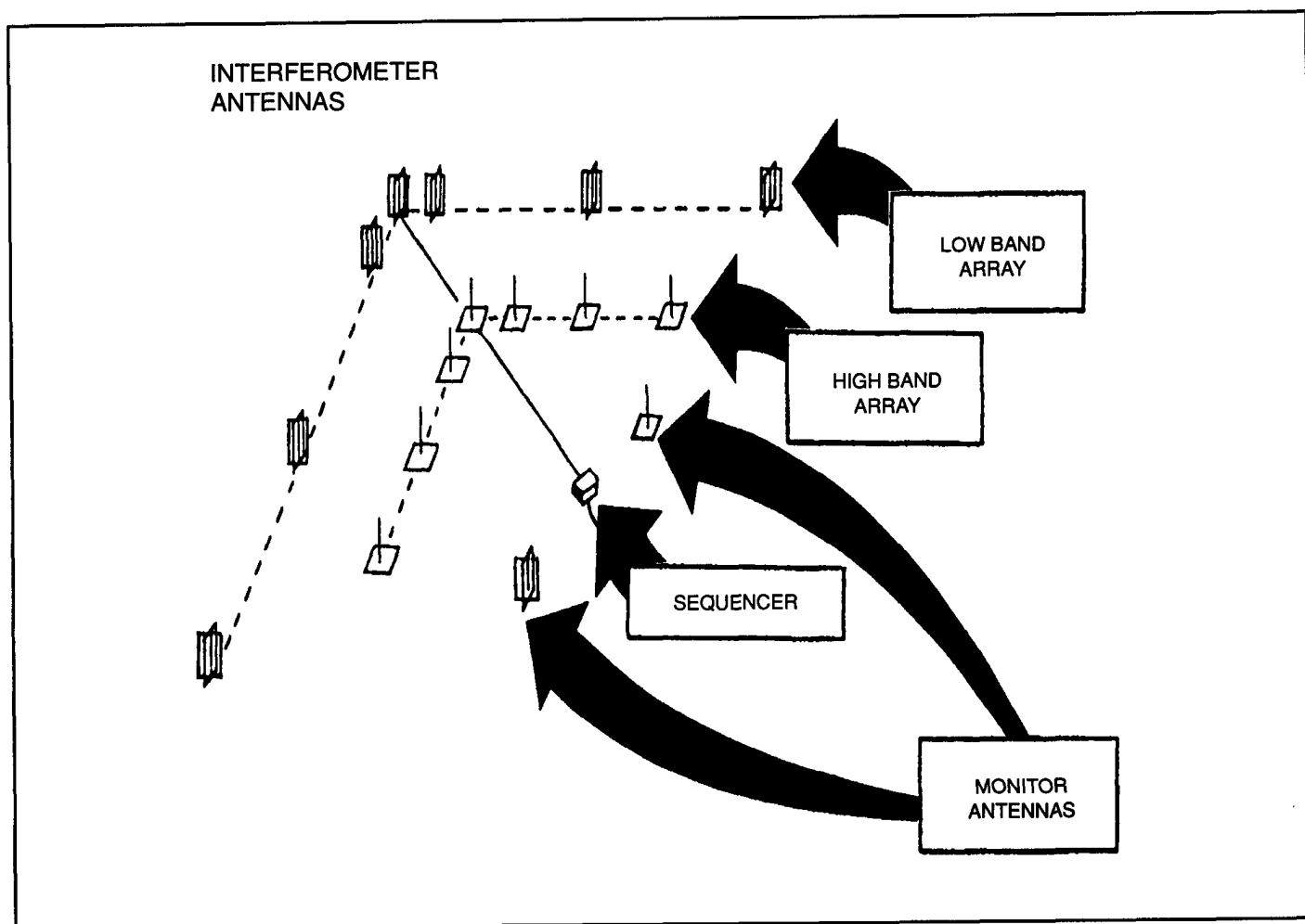


Figure 3-6. Interferometric system.

Time-Difference System

There are time-difference direction finders (TDDF) which measure the difference between the times of arrival of the radio wave at a number of receiving sites. A hyperbolic position line is obtained from the time difference between each pair of sites.

Single Station Locator System

As demonstrated earlier, there are many types of direction finding systems. In some, only the horizontal component (or azimuth) of the arrival angle can be measured. In others, the azimuth and the vertical component (elevation angle) can be obtained. When only an azimuth is resolved, two or more independent DF stations are needed to determine the position of the

transmitting antenna. Systems that measure both azimuth and elevation angles are called single station locator systems because, in the case of signals propagated in the ionosphere, two components from just one DF station are sufficient to define the location of the transmitting antenna (assuming a knowledge of the ionosphere along the wave path). The SSL was developed because of the problems of audibility with the traditional DF network. Sometimes the signal could only be heard at one DF site.

The SSL system direction finder is a phase measuring interferometer. Location data include an azimuth measurement on the target signal and a range estimate based on the measured parameters at the DF site. The combination of azimuth and great circle range to the target produces the location output from the system's computer.

DIRECTION FINDING THEORY

Quasi-Doppler Theory

The Doppler DF system is based on Christian Johann Doppler's principle for wave motion, commonly called the *Doppler effect*. The Doppler effect is the perceived change in the frequency of waves from a given source by the observer, when the source and observer are in rapid motion with respect to each other. The frequency of the wave increases or decreases according to the speed at which the distance is increasing or decreasing between the observer and source. An example of the Doppler effect is a train approaching an observer and blowing its whistle. As the train approaches at a high rate of speed, the frequency of the sound waves emitted from the whistle increase. The train passes by and leaves the observer, and the frequency of the whistle decreases.

In an idealized Doppler DF system, the motion of the receiver could be obtained by moving one antenna in a circular path as shown in Figure 3-7. With this system, the frequency of the received wave would be lower than

the transmitted frequency during the time the antenna moves with the wavefront. It would be higher than the transmitted frequency when it moves against the wavefront. No change occurs when the antenna is moving perpendicular to the direction of arrival of the EM wave. This activity produces a sinusoidal waveform across the array, such as illustrated in Figure 3-8.

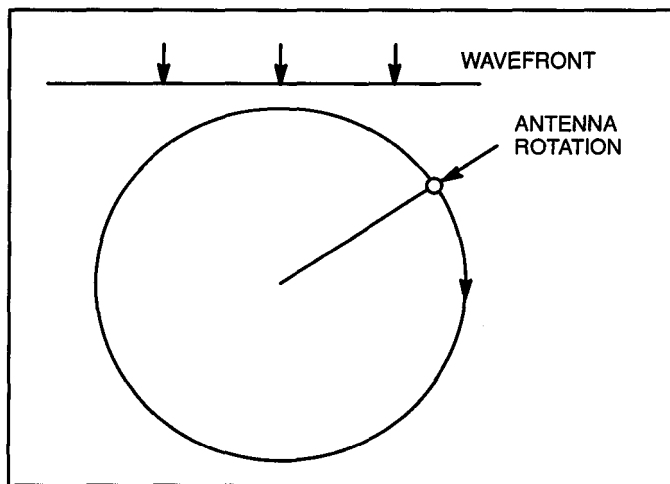


Figure 3-7. Theoretical Doppler DF.

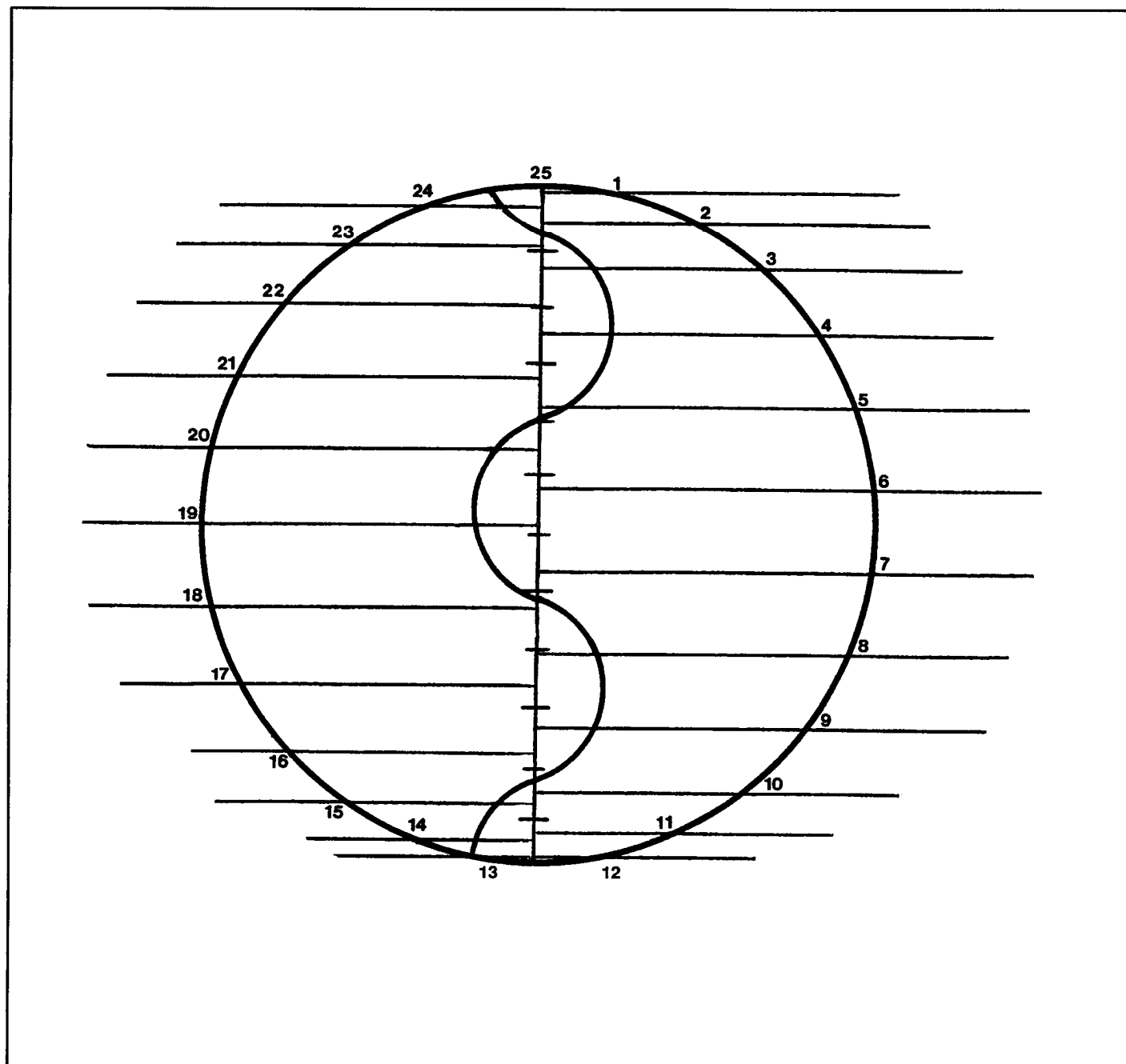


Figure 3-8. Sinusoidal waveform across the array.

The direction of arrival of the signal can be determined if the phase of the frequency modulation signal produced by the antenna motion is compared to a reference phase. The antenna peripheral speed is required to produce an adequate degree of frequency modulation. This speed is impractical to attain in a single rotating antenna system.

To create the required peripheral speed, a simulated Doppler motion is made by placing a number of fixed antennas in a circular array and scanning the signals from the antennas. This is done by sequential sampling using a rotary coupler and drive unit motor (Figure 3-9, page 3-8).

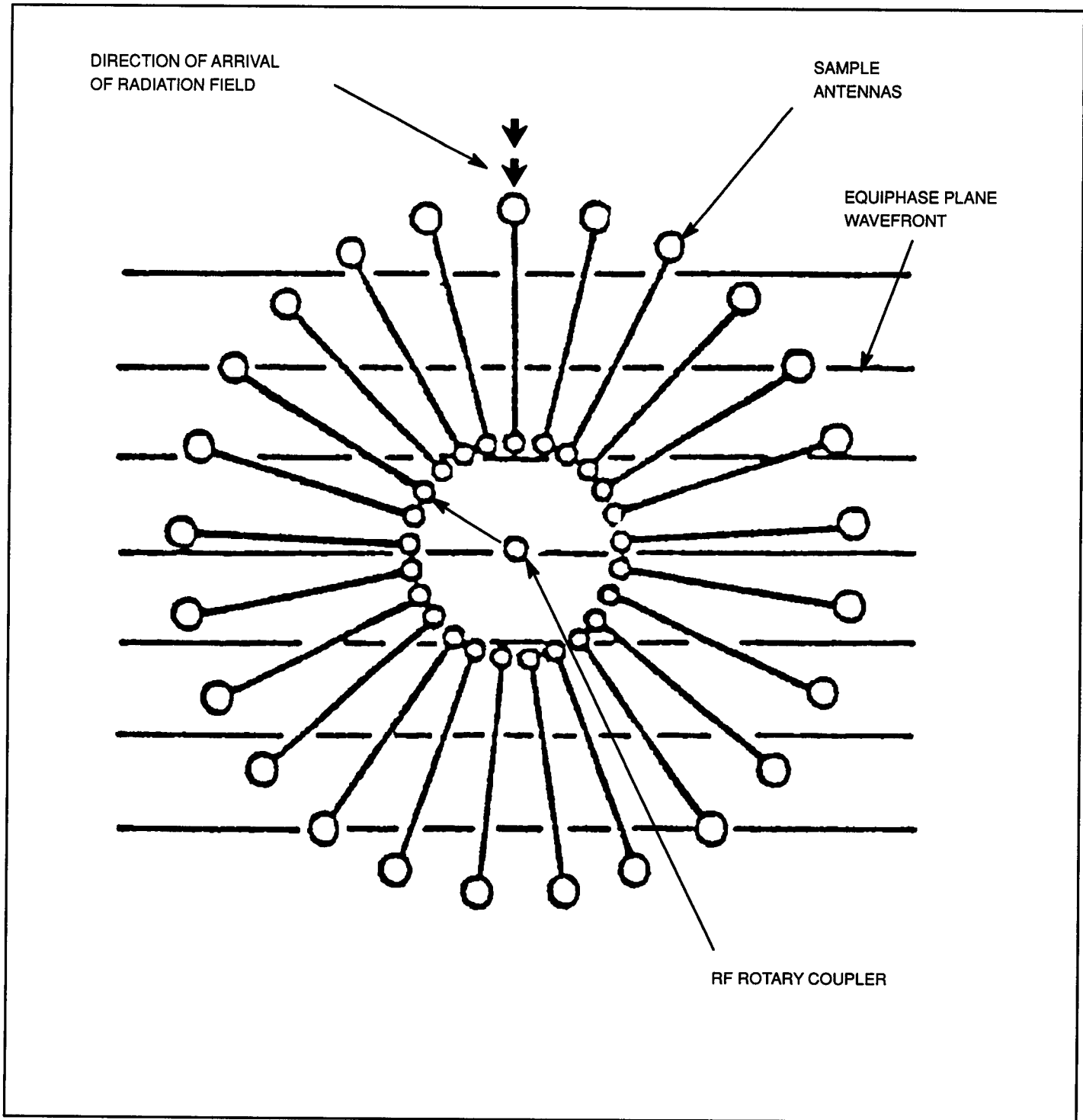


Figure 3-9. Quasi-Doppler DF.

A signal from a distant transmitter induces voltages of equal amplitude in all antennas of the array. The phase difference between the signals in adjacent antennas is a

function of the frequency and direction of arrival as shown in Figure 3-10.

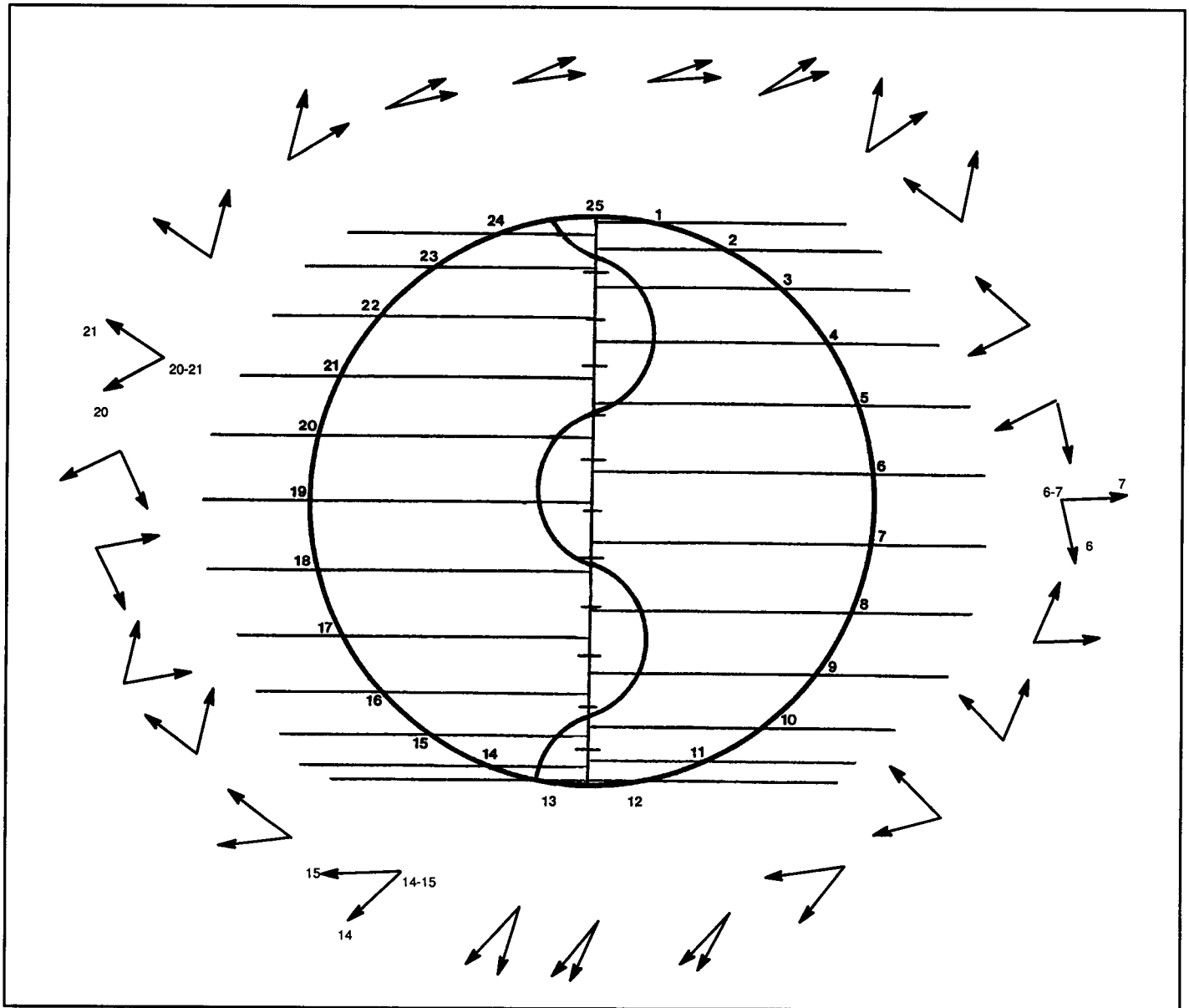


Figure 3-10. Phase difference at the antenna array.

The maximum phase step between adjacent antennas is found between those which fall on a line most nearly parallel with the direction of the wave travel. The minimum phase step occurs between antennas falling on a line most nearly perpendicular to the direction of wave travel.

The antennas of the array are scanned in sequence by a rotating coupling coil unit. The vectors revolve quickly in relation to the motion of the rotor unit. However, at any single moment, the relative phase relationships between antennas do not change with the time of

viewing or motion of the coupler. The relationship only changes with the measured frequency.

Signals from adjacent antennas are combined during the scan to produce a frequency modulated (FM) signal. The frequency deviation at every instant is proportional to the size of the phase step between adjacent antennas. The phase of the envelope of the FM depends only on the direction of arrival of the signal. A bearing indicator compares the phase of the FM envelope with a reference phase and presents the bearing indication on a CRT.

Single Station Locator System Theory

Determining a transmitting antenna's location with the SSL system requires an azimuth measurement on the target signal and a range estimate based on measured ionospheric parameters. These requirements automatically infer certain limitations on the system.

Because the SSL system depends on ionospheric propagations, it is designed for use against the high frequency (HF) spectrum sky wave transmissions. As shown in Figure 3-11, the combination of an azimuth and great circle range to the target produces a location from the system that is expressed in geographic coordinates. An HF radio wave transmitted from a target transmitter is reflected from one or more reflecting

regions in the ionosphere and arrives at the SSL site with a given bearing and angle of elevation. All SSL systems today use interferometric antenna systems to measure these azimuth and elevation angles.

The SSL system includes an ionospheric sounder which measures the height of the ionospheric reflecting region. There are two types of sounders used in SSL systems. The oldest type is the vertical incidence sounder (VIS) as shown in Figure 3-12. This sounder measures ionospheric reflection heights straight up from the sounder site (usually collocated with the SSL site). A more recent and accurate sounder is the oblique incidence sounder (OIS) as shown in Figure 3-13. The sounder, usually located along the anticipated target ray path, transmits at an oblique angle to the ionosphere and is received at another location (usually the SSL site).

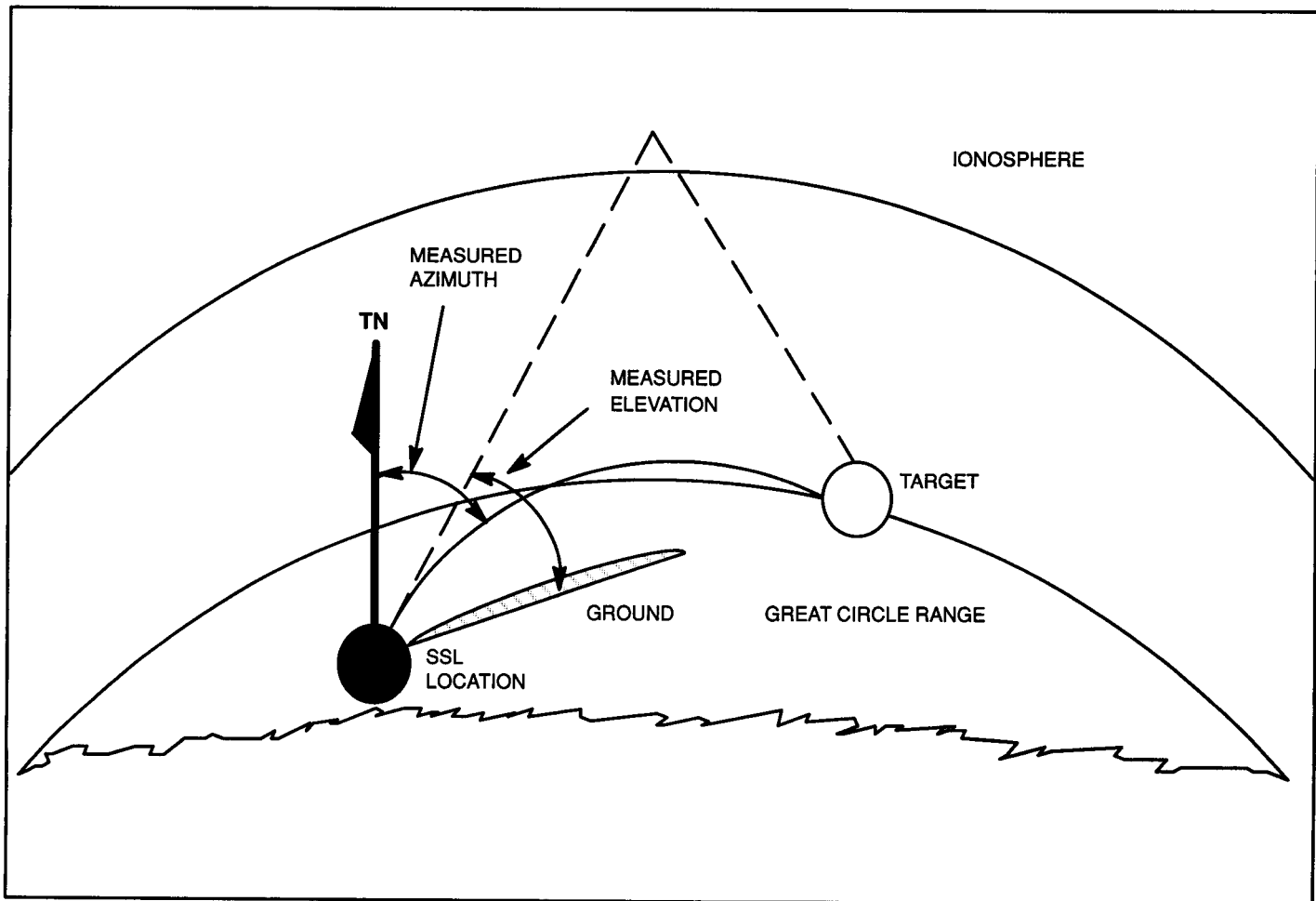


Figure 3-11. Single station locator DF.

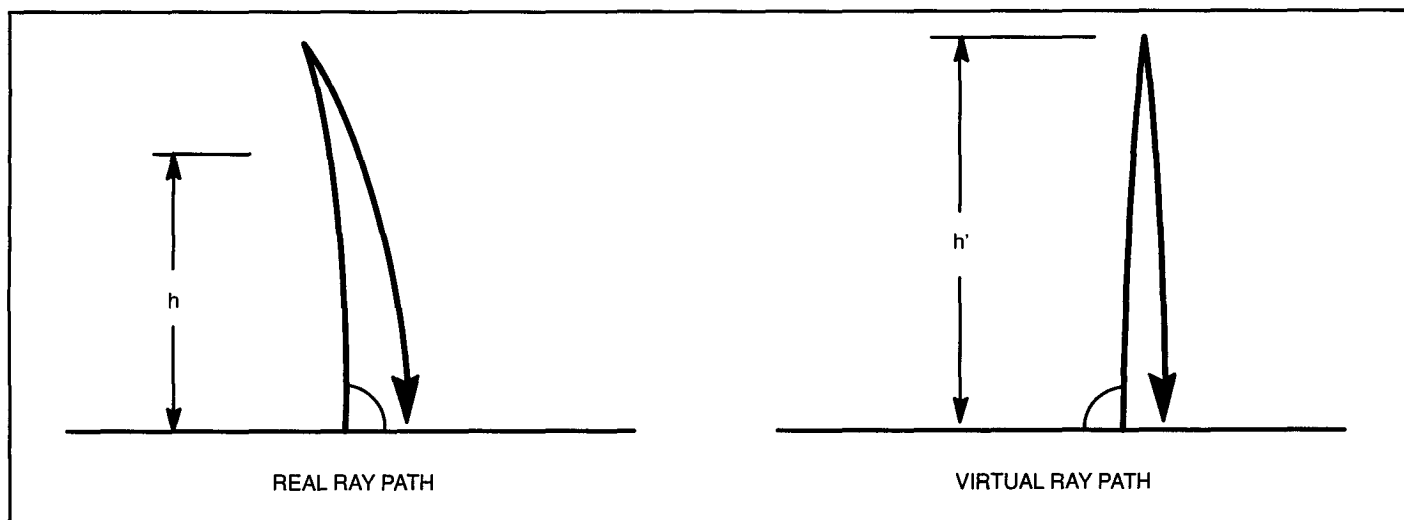


Figure 3-12. Vertical incidence sounder.

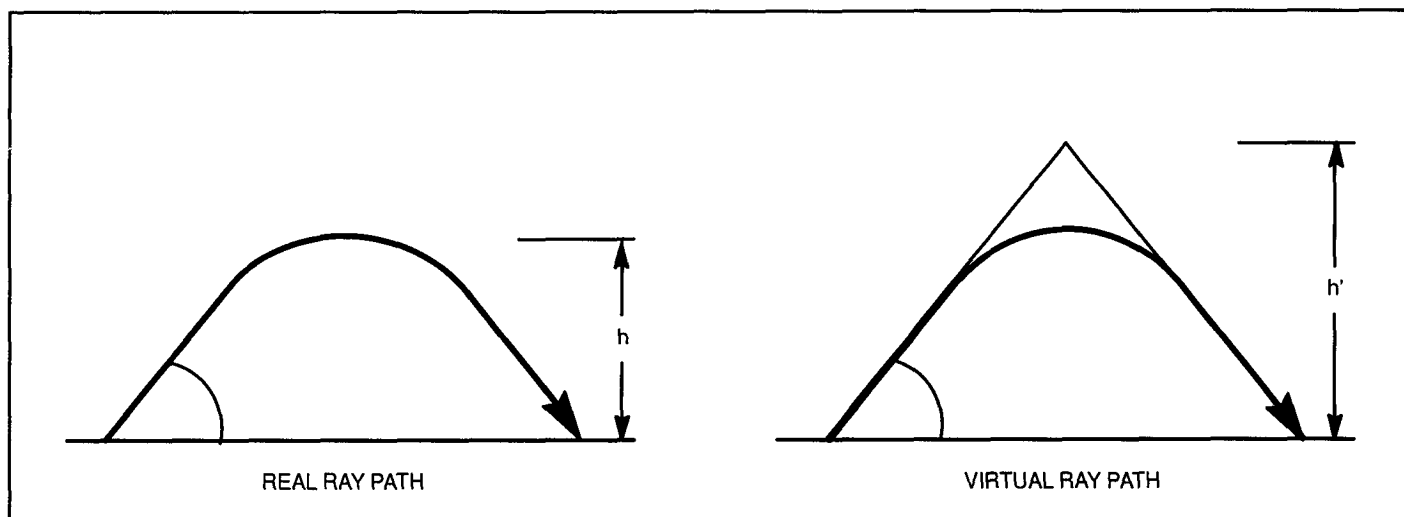


Figure 3-13. Oblique incidence sounder.

After the height of the ionosphere is measured, the SSL then assumes that the reflection height measured by the sounder applies at the midpoint of the radio wave path. Figure 3-14, page 3-12, shows the triangle from the SSL site through the ionospheric midpoint and down to the target transmitter antenna may be solved. This calculation generates a range estimate which, when combined with the observed bearing, is used to calculate the coordinates of the target location.

measured elevation and virtual height with the law of cosines to determine the angle at the center of the earth from the midpoint (half range) to the SSL system. This angle, when multiplied by twice the earth's radius, gives the great circle range from the SSL site to the target. Other systems attempt to also provide traveling ionospheric disturbances, magnetic dip angle, and electron density data in the calculations for a more accurate product.

Each SSL system has a unique way of calculating range. The most commonly found range calculation uses the

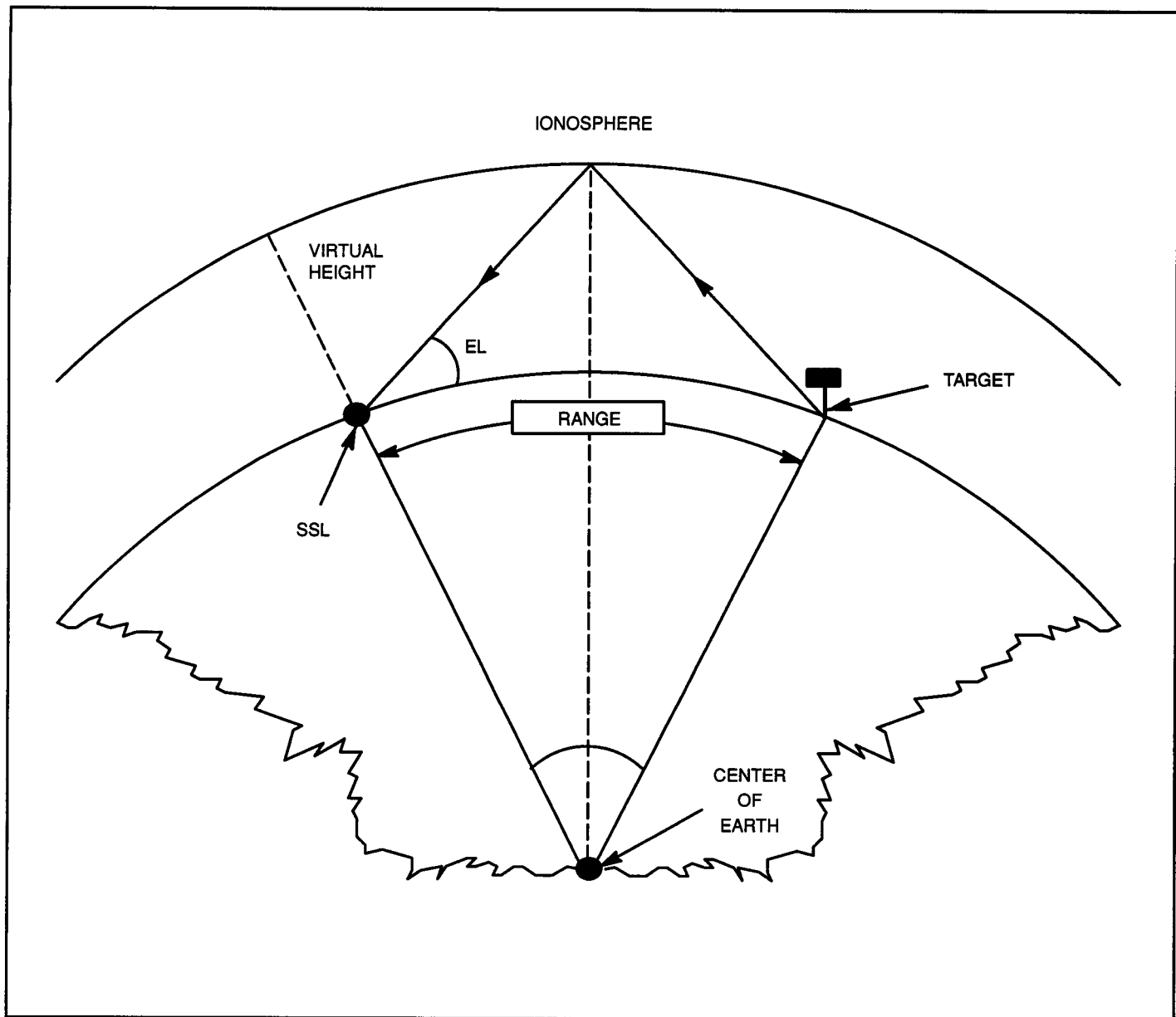


Figure 3-14. SSL operations concept.

Most SSL systems offer the following fundamental performance steps:

- The SSL computer is interfaced to the phase-measuring interferometer antenna array and to the ionospheric sounder.
- System data acquisition is controlled by a single operator.

Operator functions include—

- Identifying the target signal.
- Optimizing receiver tuning.

- Starting and terminating direction finding data collection.

Automatic functions of the systems include—

- Computing the target azimuth and elevation angles of arrival.
- Providing real-time measurement of ionospheric heights.
- Computing location coordinates.

CHAPTER 4

PERFORMANCE FACTORS

Strategic direction finding is normally conducted against transmitters located a great distance from the DF site. The radio waves are reflected or refracted by the atmosphere prior to interception. This is commonly referred to as sky wave direction finding (SWDF). Strategic DF sites at echelons above corps are normally a minimum of 150 kilometers from the forward line of own troops (FLOT).

Tactical direction finding is normally conducted against enemy transmitters located close to the DF site. The

direct wave component of the transmitted wave is normally used to locate the transmitting antenna. This is referred to as direct wave direction finding (DWDF). Tactical DF equipment is normally located within 5 to 15 kilometers of the FLOT.

Airborne radio direction finding (ARDF) is the term used to identify the DF effort conducted from an airborne platform. ARDF may be used in either a strategic or tactical situation.

STRATEGIC FACTORS

Strategic direction finding sites are quite often designed to provide DF coverage over vast geographic areas such as an entire or large portion of a continent. Nets of this nature will frequently have sites established along a baseline thousands of kilometers in length. Bearings are acquired on sky waves arriving at the DF antennas. The major influencing factors concerning SWDF operations

include the—

- Distance from the transmitting antenna.
- Sky wave propagation.
- Transmitter power.

To illustrate the distance factor, imagine a strategic direction finding site located in the skip zone (Figure 4-1).

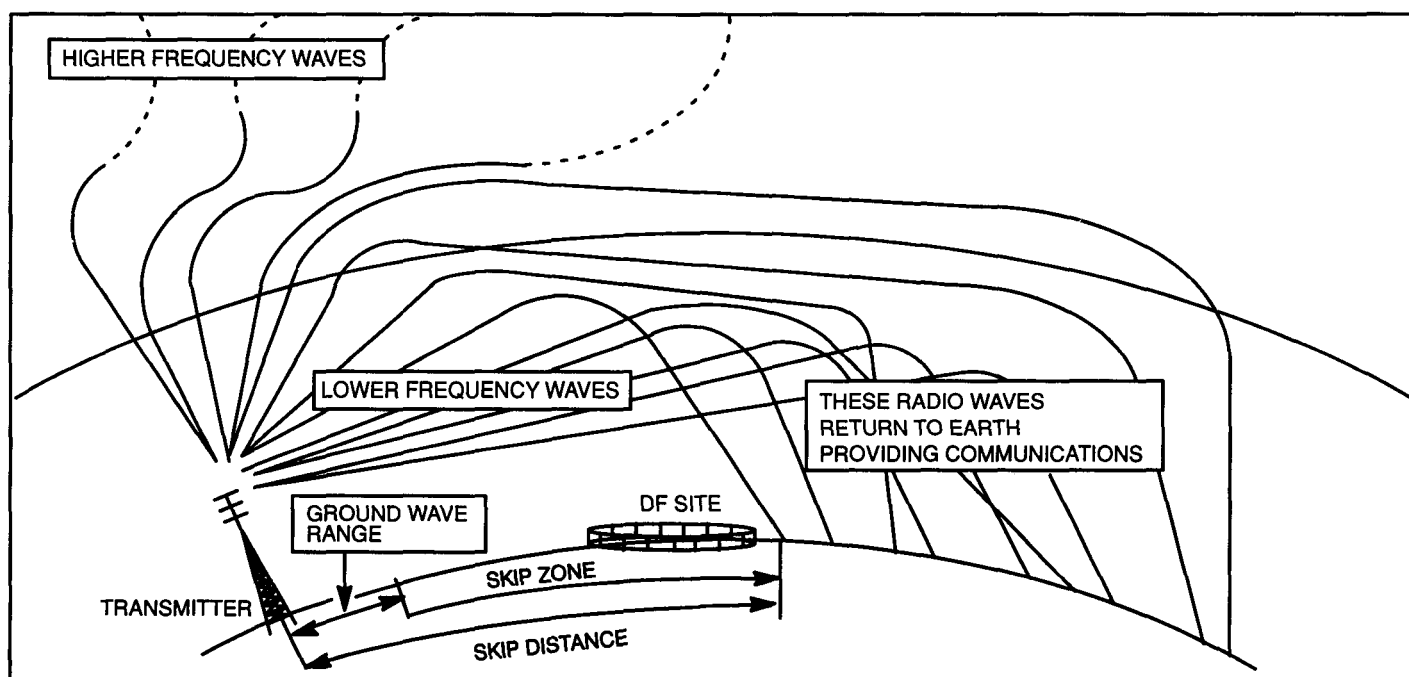


Figure 4-1. DF site located in skip zone.

The skip zone is that area where the ground wave can no longer be detected and the sky wave has not yet returned to the earth after being reflected or refracted off the ionosphere or troposphere. A SWDF site in the skip zone would not be able to receive the transmitted signal. Therefore, it could not obtain a bearing. (Strategic DF errors caused by radio wave propagation are discussed in Chapter 7.)

Sky waves and multihop transmissions (Figure 4-2) are dependent upon the frequency used and the power of the transmitter. The transmission range is affected when a low-powered transmitter is used. A signal from a low-powered transmitter that travels a great distance to the strategic site will normally be weak and fading. This results in no bearing being obtained on the signal, or if a bearing can be obtained the reliability will be questionable.

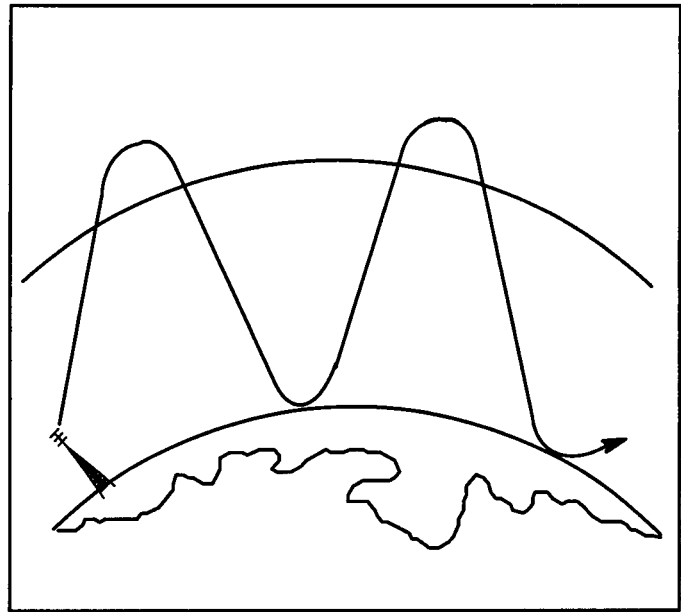


Figure 4-2. Sky waves and multihop transmission.

TACTICAL FACTORS

Consider a tactical situation where the predominant enemy frequencies used are 30 megahertz (MHz) and above. Normally, the characteristics are as follows:

- Communications are short range and line of sight.
- Frequency modulated voice is the primary type of transmission.
- Transmitters are usually highly mobile, either man-packed or vehicle mounted. They commonly use whip antennas which are omnidirectional and vertically polarized.

An important factor in tactical radio direction finding is wave propagation. The following paragraphs identify and discuss wave propagation factors.

Ground Wave

The waves radiated from a transmitting antenna spread out into the atmosphere and along the earth, as well as into the earth. Because of the conducting properties of the earth, some of the energy is reflected from the earth's surface. The part of the wave not reflected enters the earth where the energy rapidly dissipates as heat. Other portions of the waves spread out along the earth and into the atmosphere. They travel to the intended receiver as

well as to the DF set. The resulting ground wave is composed of one or more of the following wave components:

- Direct wave.
- Ground-reflected wave.
- Surface wave.

Direct Wave

Direct waves travel directly from the transmitting antenna to the receiving antenna. The direct wave is not appreciably affected by the earth's surface, but it is subject to refraction in the atmosphere between the transmitting and receiving antennas. The direct wave is the principle means of transmission in tactical very high frequency (VHF) communications, so it is important in tactical direction finding operations.

Ground-Reflected Wave

A ground-reflected wave reaches the receiving antenna after being reflected off the ground. If both the transmitting and receiving antennas are located on the ground, the difference in path lengths between a direct wave and a ground-reflected wave is small. However, these waves may arrive at a tactical DF set out of phase.

This reduces the received signal strength, particularly at frequencies below 30 MHz. Tactical communications conducted below 30 MHz are primarily with the surface wave component.

Surface Wave

A surface wave travels directly along the surface of the earth. Although it does extend above the ground, its strength is diminished with increasing height. A surface wave is affected primarily by the conductivity and dielectric constant of the ground over which it travels. It is the primary component acted upon by groundbased tactical DWDF systems taking bearings on frequencies below 30 MHz. Three important influencing factors of a surface wave are—

- Frequency.
- Terrain.
- Polarization.

Frequency. Frequency, along with transmitter power, affects the range of the signal. While ground waves are produced at all frequency ranges, sky waves are generally possible only at frequencies below 20 to 30 MHz. Any DF effort targeted above this range will be working with ground waves. Below this range, tactical equipment can actually work with sky waves and ground waves. Generally, surface wave performance is greater

at lower frequencies. These ground waves are unintentional by-products of transmissions whose main energy is directed toward the ionosphere rather than along the surface of the earth (Figure 4-3).

Terrain. Terrain is most influential on high frequency radio communications. The dielectric constant and the conductivity of the terrain over which the HF surface wave component travels can affect its range considerably. However, as previously stated, as the frequency of the transmitted signal increases, the surface wave decreases. Therefore, the electrical characteristics of the terrain have less effect on a signal as it increases in frequency.

Polarization. When a surface wave is horizontally polarized, the earth has a short-circuiting effect which causes the wave to dissipate rapidly into the ground. If a transmitted wave has some degree of both vertical and horizontal polarization, the horizontal portion will be quickly absorbed. Only the vertically polarized part of the wave will travel any appreciable distance. Because of this, it can be assumed that surface waves received can be considered to be vertically polarized. This is an important factor since most tactical DF systems employed against surface waves use monopole antennas to receive vertically polarized waves.

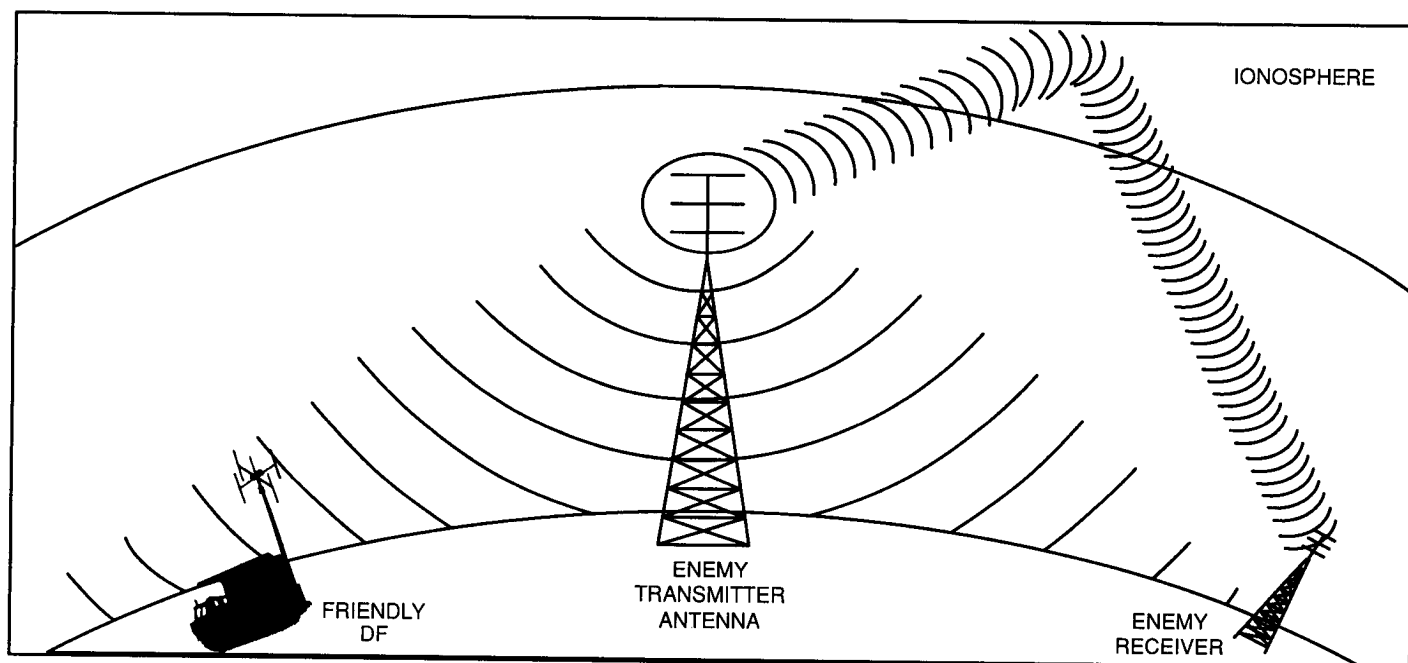


Figure 4-3. Ground wave DF.

Ground Wave Distance

The distance (from the transmitter to a tactical DF set) that a ground wave can be received is subject to extreme variations. It is affected by such factors as transmitter power, antenna type, terrain, man-made objects, and operating frequency. Advance estimates of expected

ground wave range in a given environment can be made if some knowledge of the enemy's communications equipment and operating techniques are available. However, some actual operating experience in each situation is usually required before reliable range estimates can be made.

DIRECTION FINDING BASELINES

A groundbased DF baseline is that imaginary line or axis along which the DF equipment of a DF network (three or more DF sites) are deployed. The establishment of either a groundbased strategic or tactical DF baseline is a

matter of placing the DF equipment so that good bearing angles for triangulation within the target area are possible. Triangulation is the intersection of bearings at the target area (Figure 4-4).

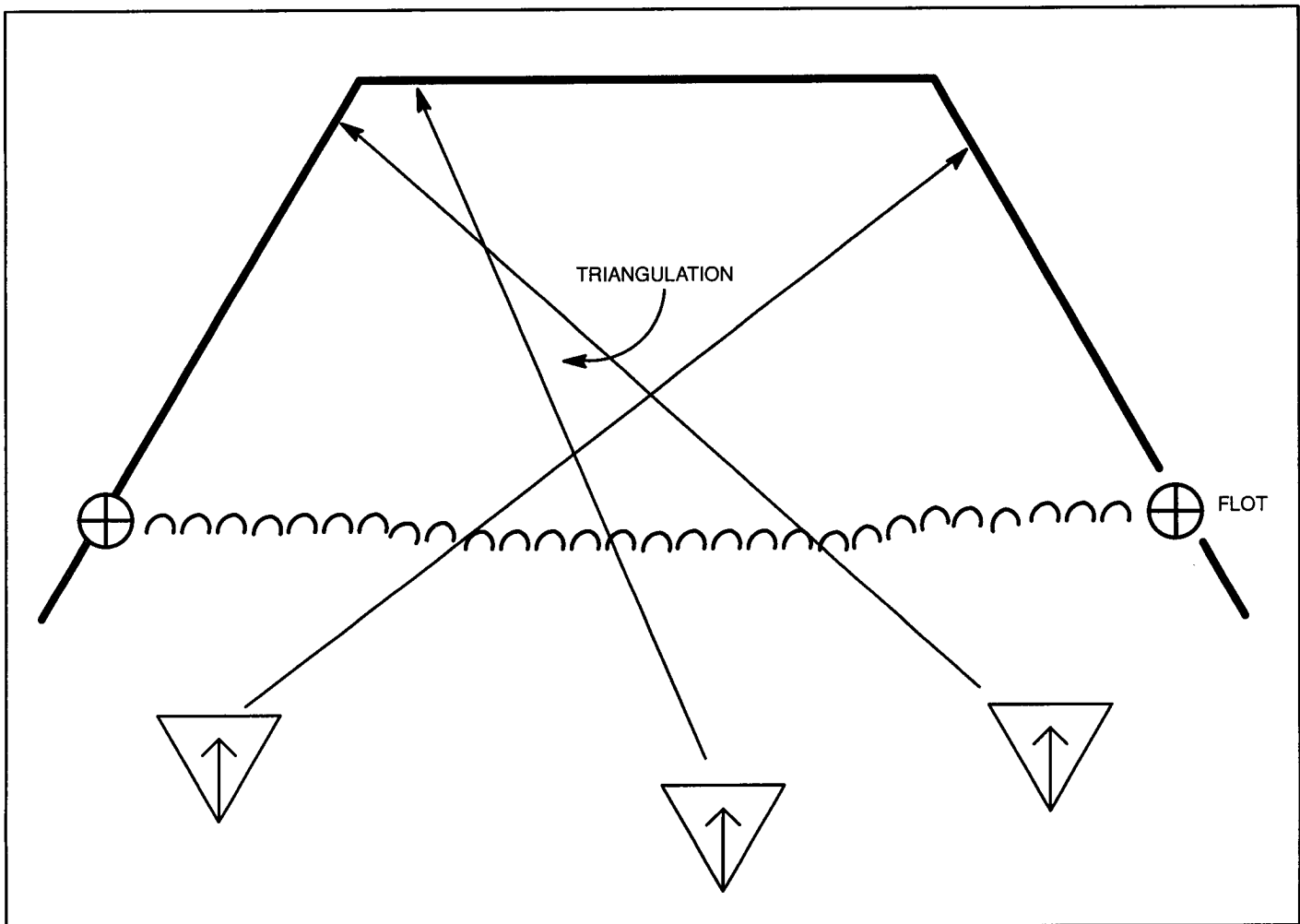


Figure 4-4. Triangulation.

Ideally, each of the DF sites should have an unobstructed wave path between the DF antenna and any point within the target area. In most cases, however, this is not possible. Tactical DF sites should be arranged so that portions of the target area that are *masked* or hidden from one or more DF sites can still be covered by at least three other sites. This is similar to setting up interlocking fields of fire for weapons. The exception, in the case of the DF equipment, is that each area must be

covered by a minimum of three *lines of fire* instead of one or two (Figure 4-5).

A masked transmitter occurs whenever the enemy takes advantage of terrain features to hide their communications from our groundbased DF operations. Masking is most effective in line of sight communications. A situation in which a site is masked is illustrated in Figure 4-6, page 4-6.

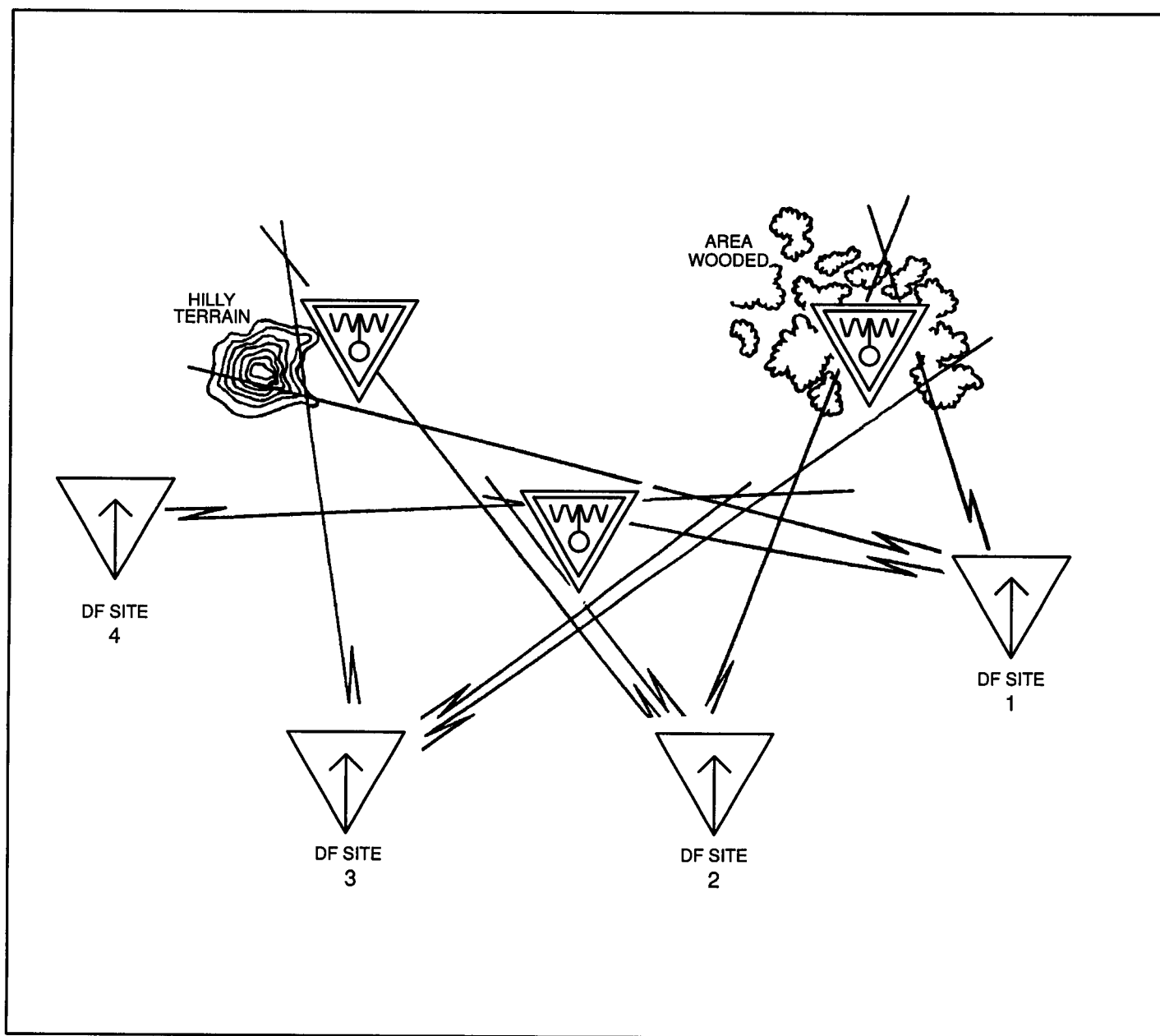


Figure 4-5. Target area coverage.

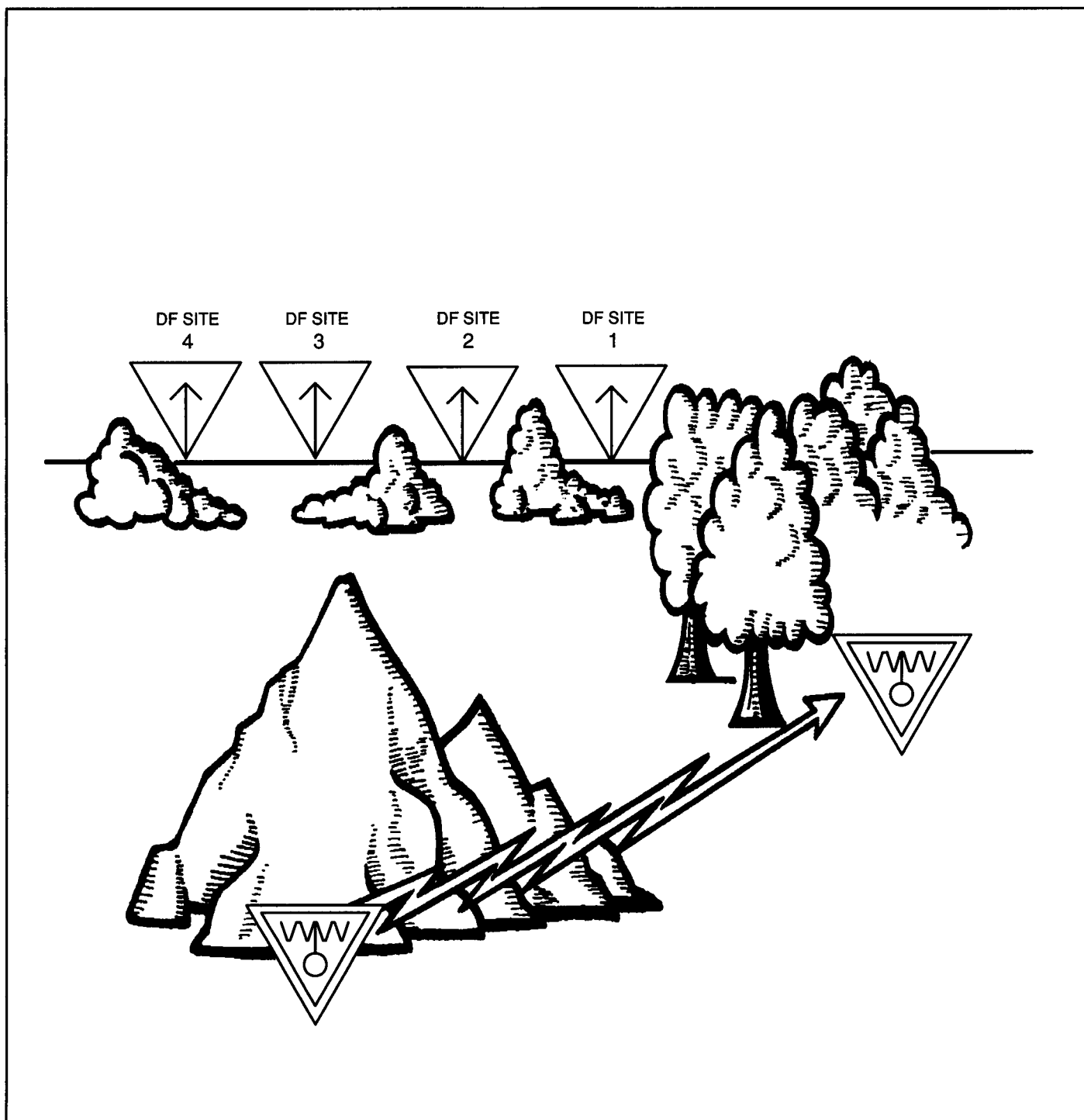


Figure 4-6. Enemy transmitter masked to our DF stations.

As you can see, when the transmitting antenna is hidden behind a hill, it is electronically hidden from the direction finding sites. However, the enemy is still able to communicate effectively with its outstation. Additionally, establishing a suitable DF baseline is

affected by tactical, strategic, and technical considerations. Essentially, there are two types of baseline configurations used to establish a ground-based direction finding network—concave and convex.

Concave Baseline

It is best to locate the DF sites on a concave baseline if it is expected that the target locations will be in a compact, narrow but deep frontal area. This situation is illustrated in Figure 4-7.

Using this baseline, triangulation from the DF site bearings is satisfactory at longer ranges. Triangulation is excellent at short ranges.

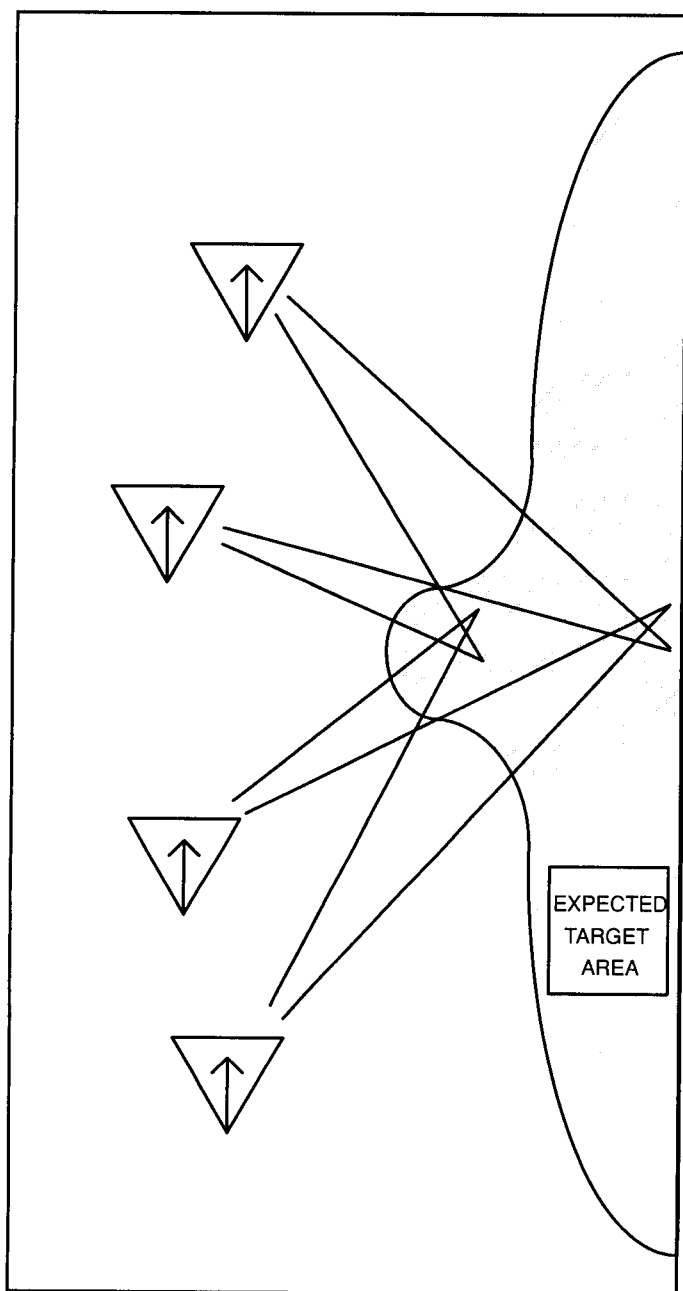


Figure 4-7. Concave baseline.

Convex Baseline

If the target locations are anticipated to be located over a wide flanking, short, in-depth area (Figure 4-8), a convex baseline is suitable.

Using a convex baseline provides a reasonable azimuth angle over a wide front. It is probable that the convex baseline will satisfy the average tactical or strategic situation.

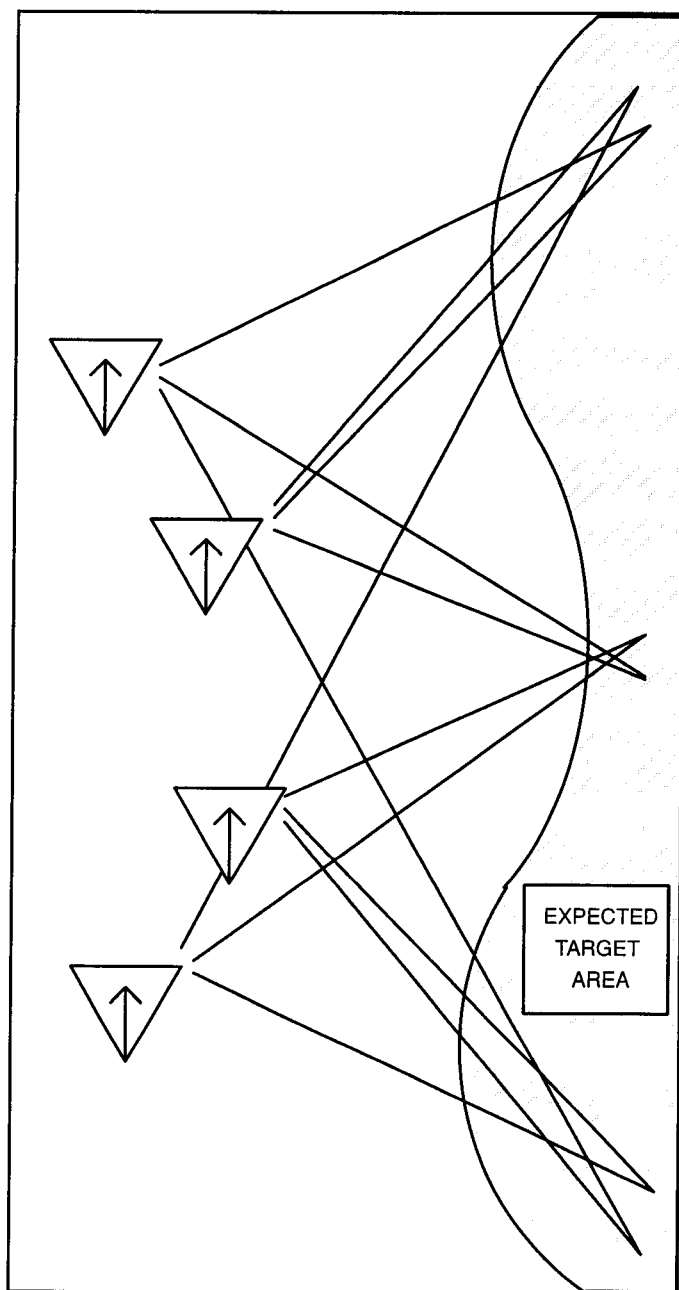


Figure 4-8. Convex baseline.

Baseline Distance

The baseline distance is a straight-line distance that separates the two outermost DF sites (Figure 4-9).

As a rule of thumb, the depth at which a DF network can effectively locate enemy transmitter antennas is equal to the total distance of the baseline joining the two outermost DF sites. This distance is then measured from the center of the imaginary baseline to the target area. For example, if the DF baseline is 80 kilometers in length, the net fix location capability is 80 kilometers in depth (Figure 4-10).

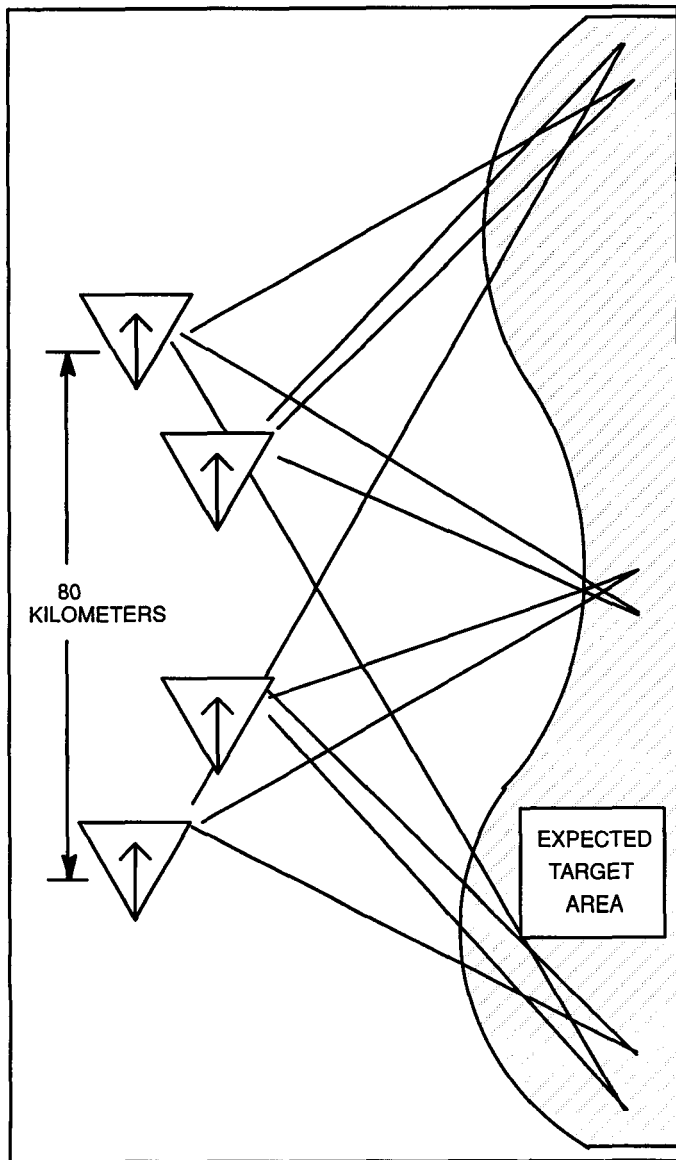


Figure 4-9. Baseline distance.

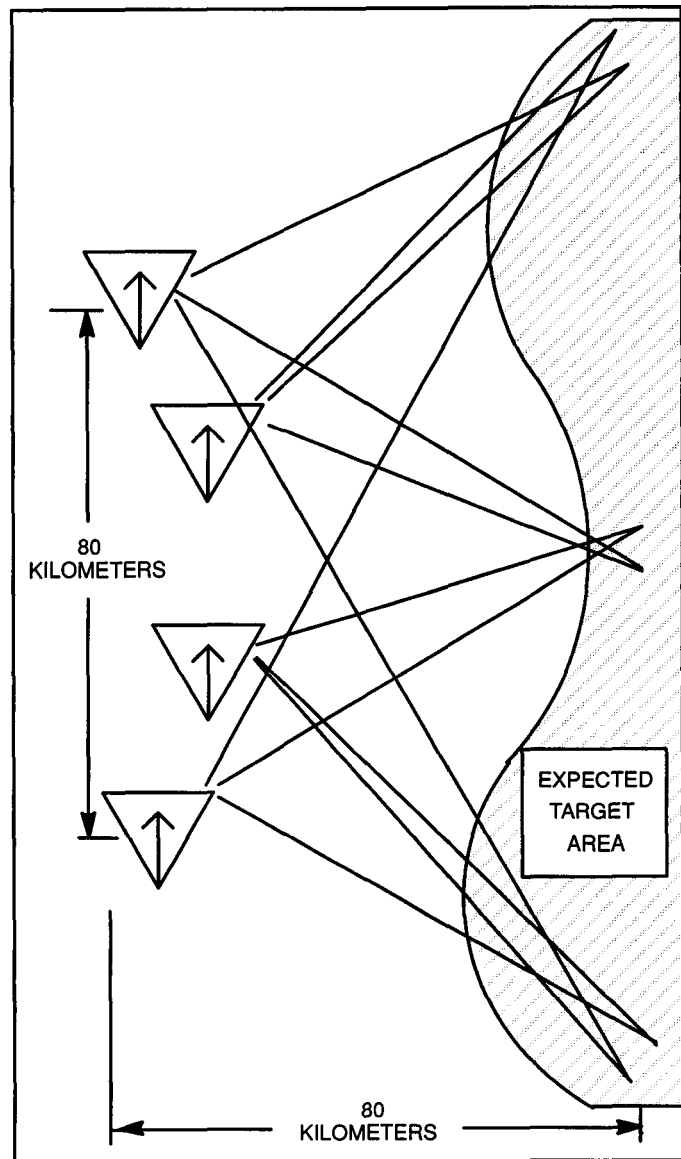


Figure 4-10. Net fix capability.

AIRBORNE RADIO DIRECTION FINDING

In the ARDF effort, aircraft are used as DF sites. These aircraft are used to supplement groundbased DF systems by providing an aerial platform to extend the radio horizon. There are several factors, however, which affect ARDF operations. The most important factors are the weather and the availability of airspace. Obviously, storms and adverse weather conditions will keep ARDF aircraft on the ground. Because ARDF aircraft operate at relatively low altitudes and slow speeds, they are vulnerable to surface-to-air missiles and hostile aircraft. Therefore, to accomplish the mission, ARDF aircraft must have the freedom of airspace.

Groundbase direction finding baseline principles are also applicable to ARDF. However, ARDF operations do not have the possible restraints that could hinder establishing

a groundbased DF baseline; for example, terrain restrictions or the availability of land. Considering that the airspace will be controlled by friendly forces, ARDF aircraft only have to maneuver for a baseline behind the FLOT. In single ARDF aircraft operations, a baseline is that flight pattern where a minimum of three LOBs or line of position (LOP) are taken on a target, resulting in the location of the target transmitter antenna (Figure 4-11).

Operations involving more than one aircraft (Figure 4-12, page 4-10) require that each aircraft fly a track which provides as wide a baseline as possible. As with groundbase systems, a minimum of three LOBs are required to accurately locate the target.

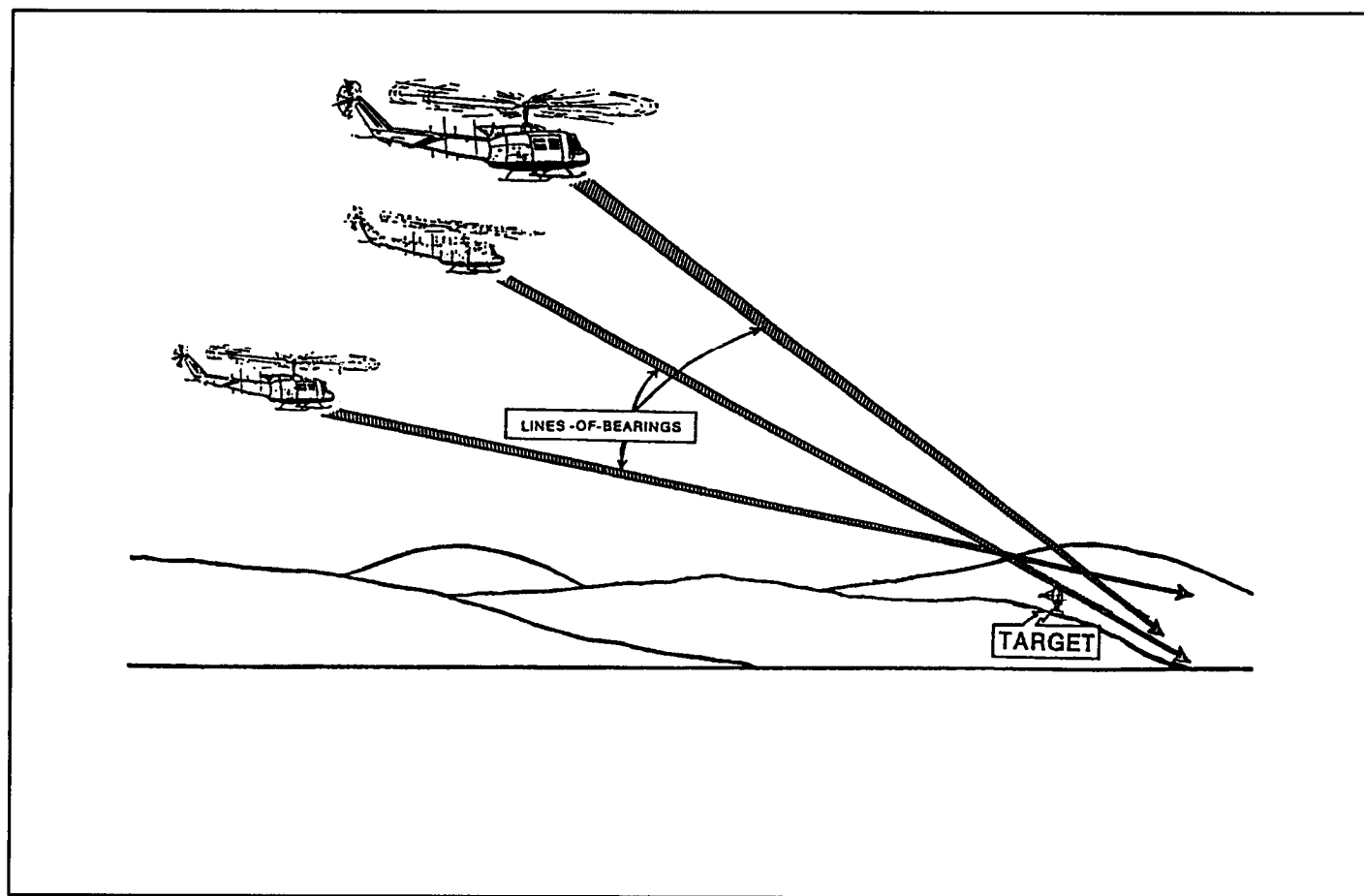


Figure 4-11. Single aircraft deployment.

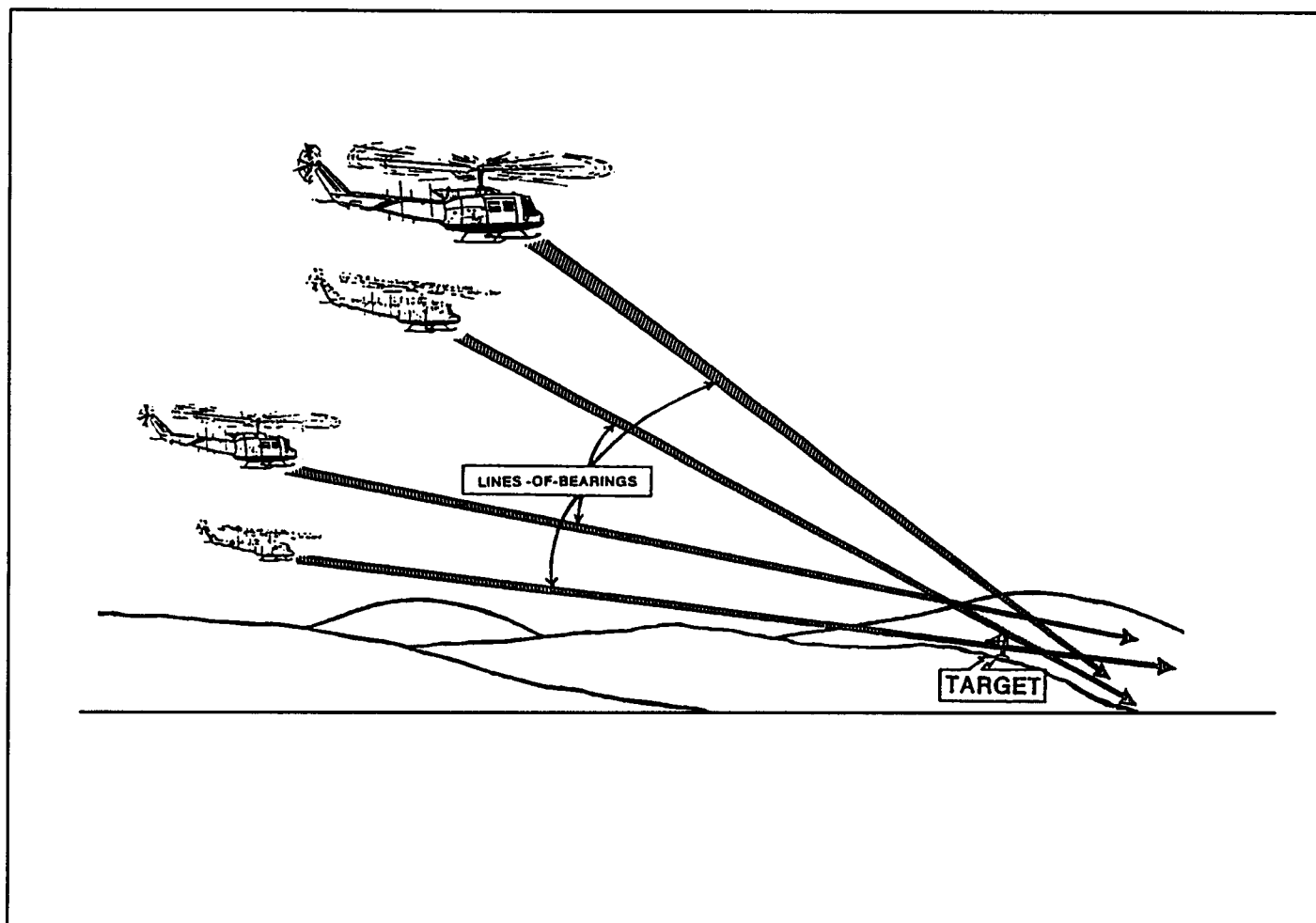


Figure 4-12. Multiple aircraft deployment.

CHAPTER 5

SITE DEPLOYMENT

It is not the intent of this section to address all aspects of a strategic or tactical direction finding site. Rather, the purpose is to establish general guidelines for use in strategic and tactical DF site deployment.

NOTE: EAC groundbased DF can be employed in semifixed or mobile configurations, as either strategic or tactical assets.

STRATEGIC

Normally, EAC and strategic direction finding sites are distantly located from their net control station (NCS). A noncommissioned officer, referred to as the DF site supervisor, is in charge of an EAC or strategic DF site. In many cases, these direction finding sites are not located near any military support activity. Therefore, as the direct representative of the commander, the duties and responsibilities of the site supervisor are diversified and numerous. The site supervisor is directly responsible to the commander for—

- **Mission.** This includes the day-to-day site operation (equipment operation and maintenance) and accomplishing the mission as directed by the NCS.
- **Security.** This includes physical security of the DF site (equipment and personnel) and classified information security (communications security (COMSEC)).
- **Personnel.** This includes the health, welfare, recommendation for promotion, discipline, and counseling of DF site personnel.

TACTICAL

A team chief is normally in charge of tactical communications and noncommunications DF site operations. A team chief is directly responsible to the platoon leader for—

- **Mission.** This includes the day-to-day operation (equipment operation and maintenance) and accomplishing the mission as directed by the MI

battalion tactical operations center (TOC) (division) or the MI brigade TOC (corps).

- **Security.** This includes survivability of the equipment and personnel in a hostile environment.
- **Personnel.** This includes the health, welfare, recommendation for promotion, discipline, and counseling of DF site personnel.

SITE LOCATION

Regardless of whether a DF site is strategic or tactical, once it has been installed its location must be accurately determined and reported. If a site's location is erroneously calculated, reported, and placed on a plotting map or entered into a computer, it will result in

an inaccurate determination of target locations. There are three methods of determining a site location—

- Resection.
- Geodetics.
- Satellite derived, global positioning system (GPS).

Resection

Determining the location of a DF site by sighting two or three known features, from the DF site, is called resection. First, orient the universal transverse mercator (UTM) 1:50,000 map using the compass. Locate the two or three known positions on the ground and mark them on the map. Using the compass, measure the magnetic azimuth from the DF site to one known position. Convert this azimuth to a grid azimuth. Change the grid azimuth to a back azimuth (refer to FM 21-26) and draw a line on the map from the known position back toward the DF site. Repeat for each known position. The intersection of the lines is the location of the DF site (Figure 5-1). Using three lines, a triangle may be

formed. If this triangle is large, check the procedures. *Do not* assume the DF site is located in the center of a large triangle.

Geodetics

Geodetics is the determination of a site's position through the use of mathematics and the positioning of celestial bodies. Due to the complexity and time involved in the computation, this method normally is used for permanent strategic DF sites. This field manual does not provide the computation procedures.

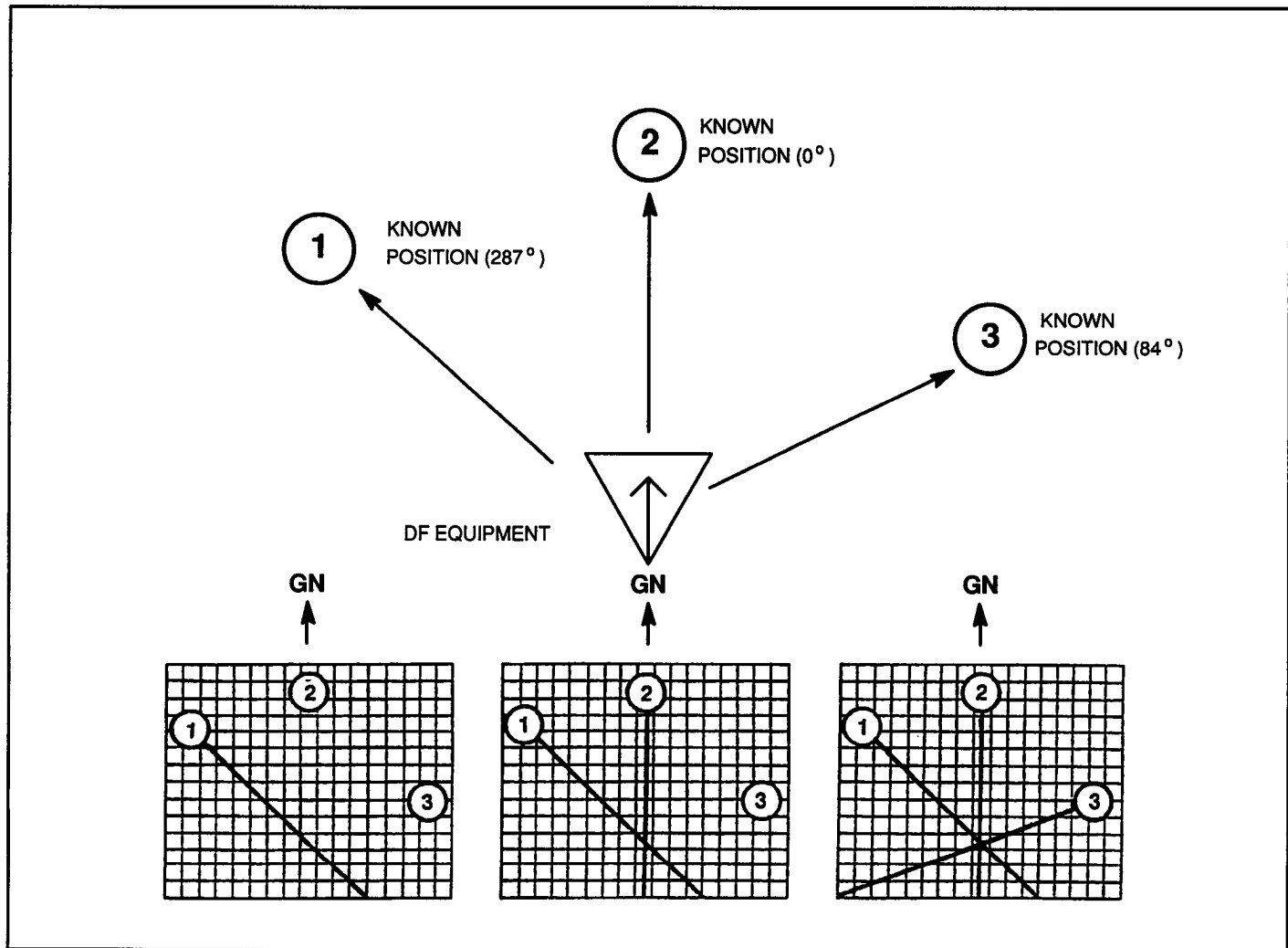


Figure 5-1. Resection.

SITE ORIENTATION TECHNIQUES

Whenever DF equipment is installed in a new location, it is necessary to orient the site's antenna(s) to either true, magnetic, or grid north. What orientation method used depends on the equipment employed and the established reporting criteria for LOBs.

True, Magnetic, and Grid North

True north is the actual direction of the earth's north pole. Magnetic north is the direction of the north magnetic pole. It is indicated by the N (north seeking) end of the compass needle. Grid north is the direction of the vertical grid lines usually found on military maps. The difference in direction between true north and magnetic north, or between true north and grid north, is known as declination (Figure 5-2).

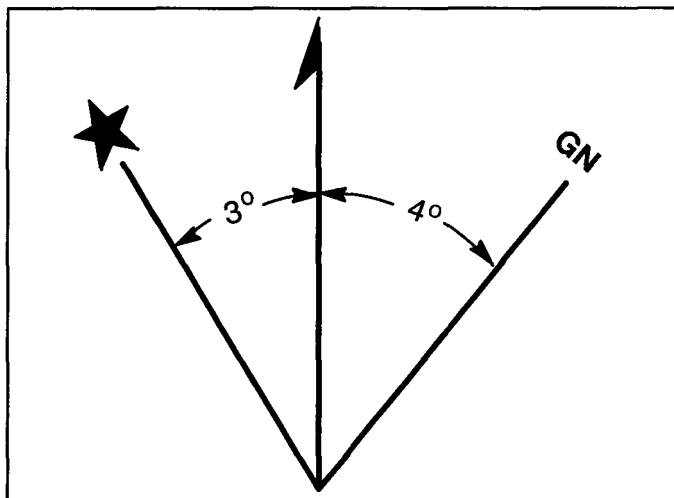


Figure 5-2. Declination diagram.

True North Declination

True north declination is the fixed difference in direction between true north and grid north. True north declination varies in different localities. Actually, it varies at different points on any one map, but on a tactical map the variation is so slight that the average declination can be used without introducing an appreciable error.

Magnetic Declination

Magnetic declination is the angle between true north and magnetic north. In localities where a compass needle points east of true north, magnetic declination is east. Where a compass needle points west of true north, the magnetic declination is west. Where true north and magnetic north are the same, magnetic declination is zero. The magnetic declination in any given locality is subject to gradual change, the amount of which can be calculated from the declination diagram. Annual change is frequently expressed as E or W (east or west) to avoid ambiguity in the change of direction.

SITE CRITERIA

The following site criteria should be used as a guide in selecting either a strategic or tactical DF site location. These are optimum considerations that cannot always be achieved, especially under tactical conditions. For example, a volatile tactical situation, the availability of land in strategic and tactical situations, and many other factors may require some site criteria compromise. Site criteria is as follows:

- The area should be substantially flat for approximately 90 meters from the DF antenna(s). It should also have no more than a gentle slope for at least 180 meters.
- The area should be the highest level area in the vicinity. A site in a valley is usually unsatisfactory.

- wavelengths of the lowest frequency to be used for
- If the DF site must be placed on or near a shoreline, it of interest (Figure 5-3).
- The earth at or around the site should have uniformly high conductivity and moisture content. Areas meet this requirement. Rocky or sandy soil is a poor location for a direction finding site. However, areas having low conductivity are preferable to areas having high conductivity spotted with rock formations, sand, or a varying moisture content.
- Regions where there are abrupt gaps or changes in elevation of the earth should be avoided. Sharp changes in terrain elevation usually indicate the presence of rock or mineral outcroppings or underground streams.
- The site should be removed from buildings, wire fences, power or telephone lines, radio antennas, railroad tracks, buried metal conductors (cables and pipelines), sharp ground contour changes (mountains, cliffs, and ravines), chimney stacks, water towers, rivers, lakes, and streams.
- Distances to be maintained between the direction finding site and these obstructions, to minimize their effect on accuracy, are listed in Table 5-1.

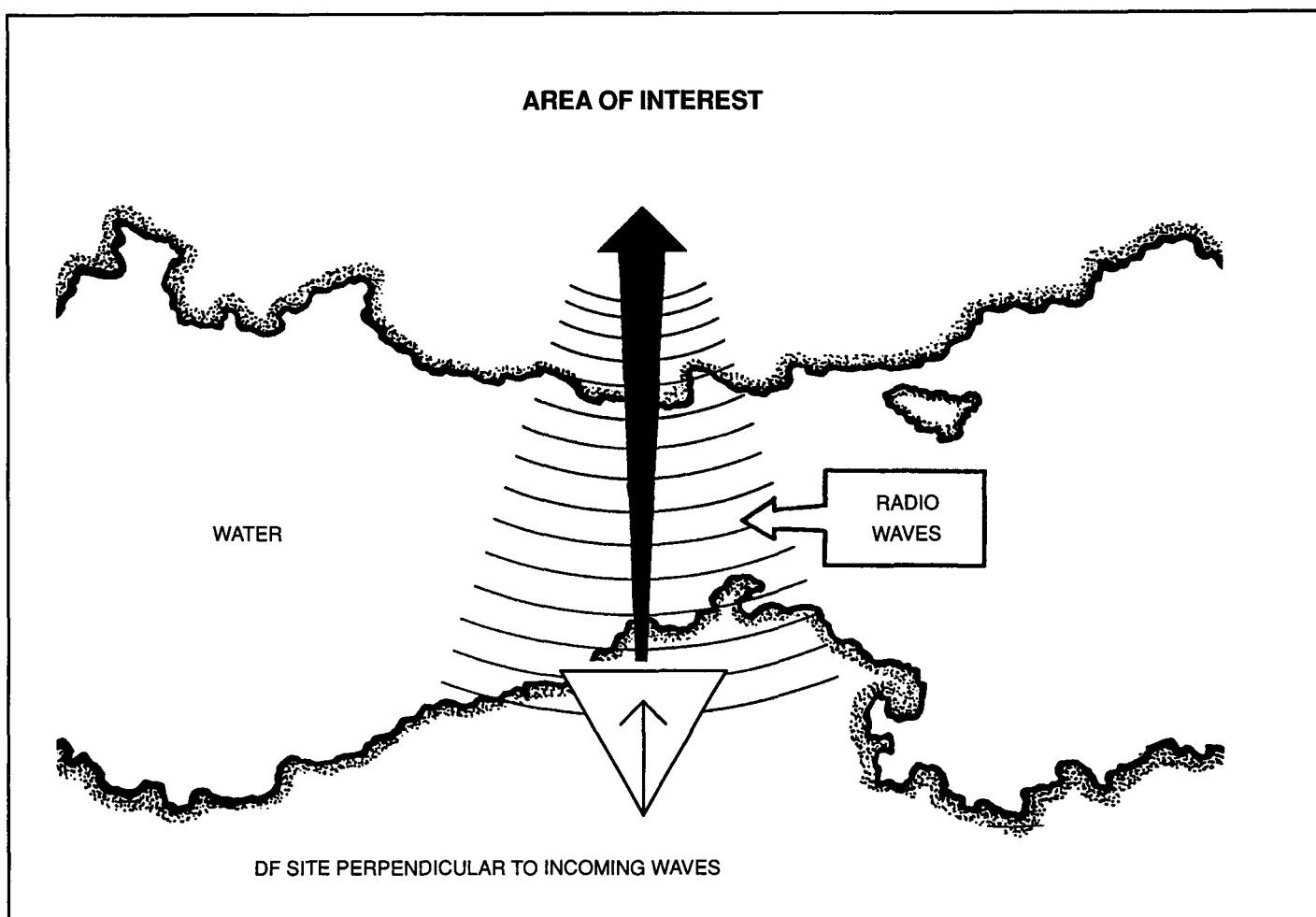


Figure 5-3. DF site located on the coast.

Table 5-1. Preferred distance to be maintained from obstacles.

OBSTACLES	DISTANCE TO BE MAINTAINED
Scattered trees and single small buildings.	185 meters
Wire fences.	275 meters
High cliffs and deep ravines.	1.6 kilometers or farther
Buried metallic conductors.	275 meters
Chimney stacks and water towers.	450 meters
Railroad tracks and overhead conductors (utility lines and antennas).	450 meters
Mountains.	10-50 kilometers
Rivers, streams, and lakes.	550 meters

Strategic Guidelines

The specific guidelines apply for strategic direction finding systems. Some strategic DF sites may not be able to adhere to the following criteria due to environmental, climatic, geographic, or political conditions. In these cases, the NCS of that site is responsible for considering and approving any exception—

- The DF shelter should be located in the quadrant of least interest (where incoming enemy signals are not expected). It should be as far from the antennas as the real estate will permit (Figure 5-4, page 5-6).
- The DF antennas should be positioned in the area of primary interest (where incoming enemy signals are expected). The antennas will be as far from other site equipment such as vehicles, generators, and petroleum, oils and lubricants (POL) as the real estate permits.
- No structure or other equipment should be located closer than 300 feet from the nearest DF antenna or in line of the area of prime interest. All incoming power cables should be buried to a depth of at least 1 foot, beginning a minimum of 500 feet from the site area. Power cables inside the DF antenna array or within 50 feet of the antennas should be buried to a depth of at least 3 feet. The direction of buried electrical cables should be indicated by nonmetallic cable signs posted every 200 to 500 feet.
- Strategic DF sites should be declared a restricted area by the commander and posted with nonmetallic signs. Signs should not exceed a height of 3 feet. They should be printed in black letters on a white background. Where required, the signs should be multilingual. Signs should be spaced approximately every 100 feet along the perimeter of the DF antennas. The signs should also be positioned so that they face all quadrants of the DF site.
- Perimeter lights should be placed within 5 feet of each corner of the equipment facing outward. The lights should not exceed 5 feet in height. Electrical wiring for the lights should be kept to a minimum length and buried to a depth of 3 feet.
- Associated equipment such as vehicles, generators, supply shelters, and POL should be arranged so as to lie along a center line opposite the area of primary interest. Vehicles should be parked as far away as possible, with a minimum of 500 feet. They should always be parked in the area behind the quadrant of least interest.

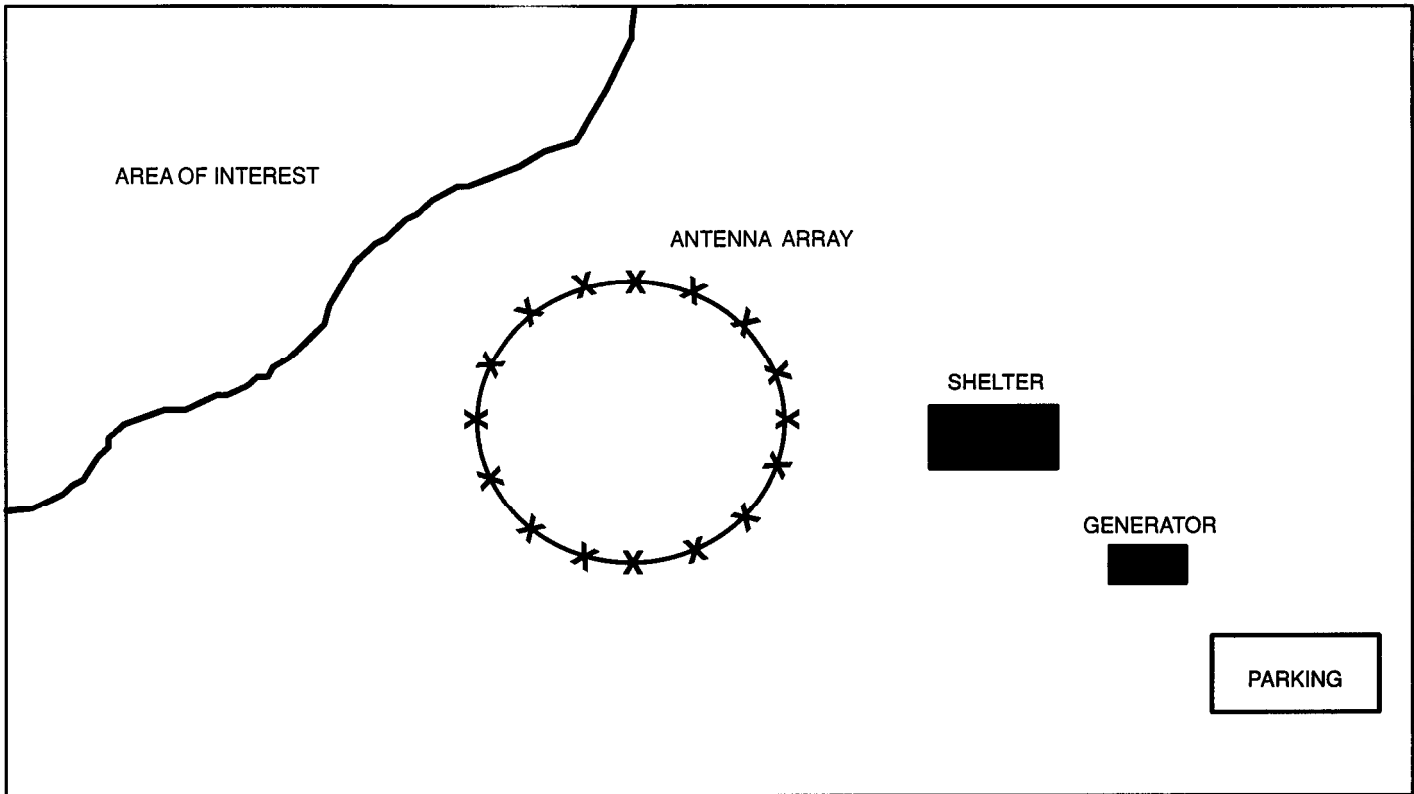


Figure 5-4. DF shelter located outside of antennas in the area of least interest.

Tactical Guidelines

It would be impossible to address every tactical situation in which the platoon leader and team chief might find themselves. Therefore, the following paragraphs will provide general guidelines on tactical site selection and battlefield survival.

A primary consideration in selecting a tactical intercept or DF site location is the ability to receive the target emitter signals from the area of interest. A major consideration for deployment of tactical DF systems is obtaining radio LOS for targets. Radio line of sight is the straight-line path between a transmitting and receiving antenna that is not blocked by the curvature of the earth (Figure 5-5).

Good VHF communications depend on LOS radio wave propagation. Likewise, tactical groundbased DF systems must be deployed within LOS range of the area of interest for intercept and direction finding. Additionally, DF sites must be able to communicate with their NCS.

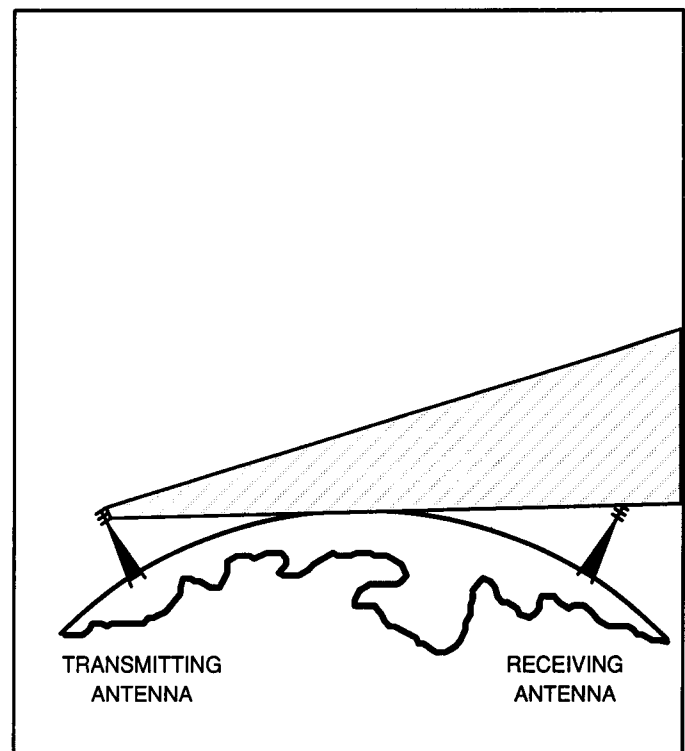


Figure 5-5. Line of sight restrictions.

All tactical intercept or direction finding systems have common requirements that must be met if the equipment is to provide combat information and intelligence to the supported commander. These requirements are—

- Ability to intercept the enemy signal.
- Effective DF baseline.
- Freedom from enemy detection.
- Close proximity to supported elements.

Ability to Intercept the Enemy Signal

Wide variations in the signal strength may exist within relatively small areas. Hills and mountains between the enemy transmitting antennas and the intercept/direction finding equipment limit the quality of intercept and could cause inadvertent DF errors. (Further information

is provided in Chapter 7.) The direction of arrival of the enemy's signal can also be affected by barbed wire, armored vehicles, or other metallic objects that could possibly negate the site's original technical advantages. Enemy VHF signals normally are not affected by the ground on which they travel. However, signals are reflected and reradiated by objects in their wave path. Obstructions in the near vicinity of the site are particularly objectionable. The closer the obstruction is to the DF site, the greater its adverse effect on the site.

Effective DF Baseline

An effective DF baseline must be established. As previously discussed, a direction finding baseline is normally convex or concave to the target area (Figure 5-6).

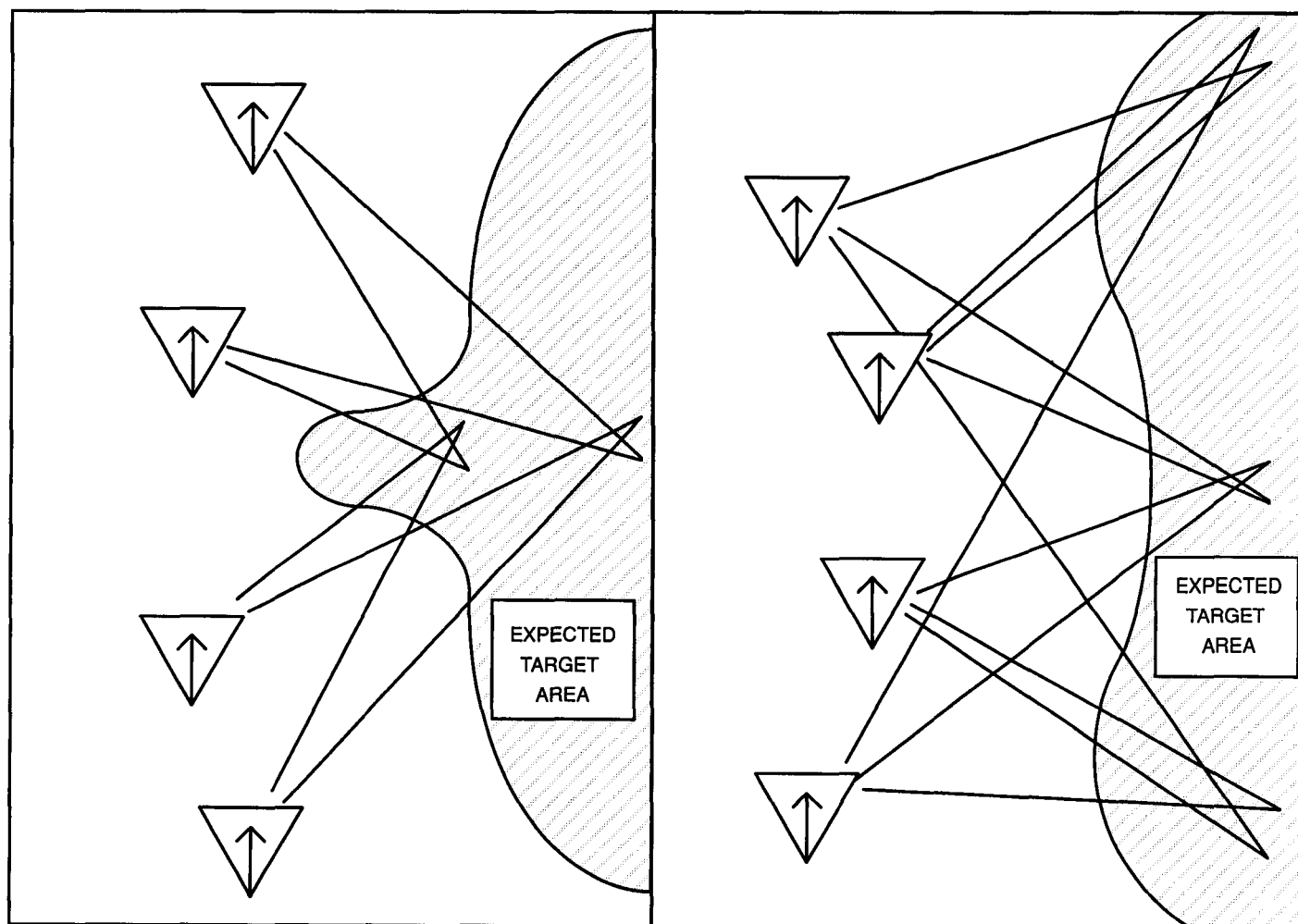


Figure 5-6. Concave and convex baselines.

As illustrated in Figure 5-7, when the tactical DF baseline is approximately 20 kilometers in length, the effective target area depth is approximately 20 kilometers. There are instances when the need for establishing an adequate baseline to locate enemy transmitter antennas requires placing one or more direction finding systems in an undesirable location. If an effective baseline cannot be established, direction finding results may be unsatisfactory.

Freedom From Enemy Detection

Intercept/direction finding personnel should have the freedom to perform their mission during combat to provide current intelligence and combat information. Military intelligence personnel are armed with individual

weapons, but this is not sufficient to engage an enemy combat unit. Therefore, the intercept/direction finding system and the survival of personnel depend on their ability to operate undetected by the enemy. Combat should be avoided if at all possible. Intercept/direction finding equipment destroyed during combat may not be replaced for the duration of the conflict. Platoon leaders and team chiefs should look for good potential concealment when locating a site. They must become experts at camouflage. Locations selected for intercept/direction finding operations should provide the best cover and concealment possible consistent with good reception. However, some amount of signal impairment must be tolerated if the intercept/direction finding system and personnel are to survive in a tactical environment.

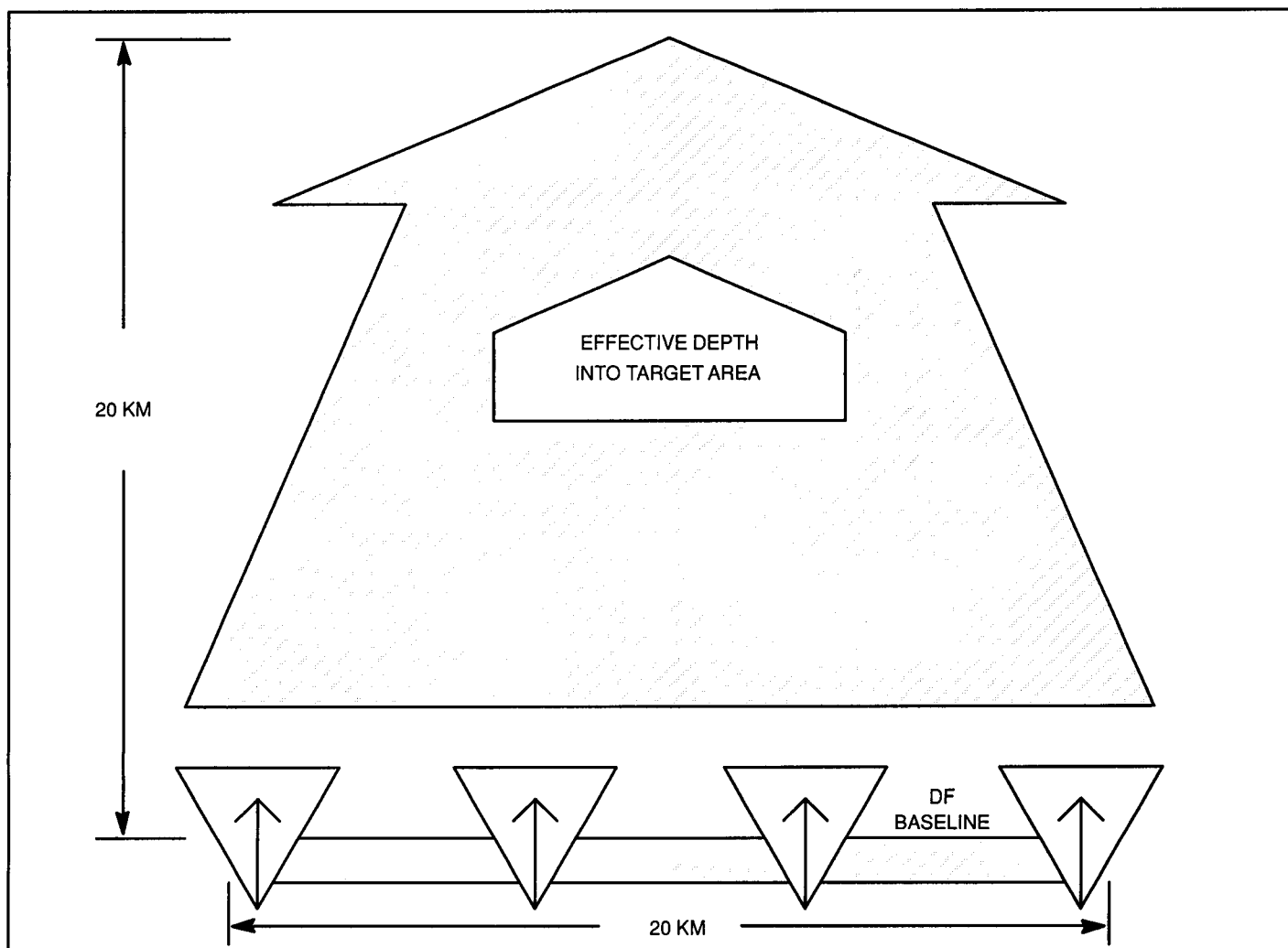


Figure 5-7. Baseline effectiveness.

Close Proximity to Supported Elements

The intelligence and electronic warfare support element (IEWSE) is the MI battalion's liaison to the maneuver brigade. The maneuver brigade commander and staff work closely with the IEWSE to develop an intelligence plan which will effectively integrate electronic warfare (EW) support into the operational scheme. The IEWSE coordinates and resolves terrain siting conflicts of all the MI battalion assets within a supported brigade's sector.

The IEWSE closely coordinates with the S3s of the maneuver brigade and the MI battalion. The IEWSE ensures that essential information on the progress of the maneuver brigade operations is passed to the MI

battalion TOC so timely mission adjustments can be effectively integrated into the maneuver effort.

The company team commander is responsible for coordinating support with neighboring units for the MI battalion assets within an assigned maneuver brigade area. The company team commander, the IEWSE, and the MI battalion S3 work closely together on mission requirements and combat service support for the deployed platoons, so that the deployed platoon leaders can concentrate on mission accomplishment. If a platoon is deployed into a sector and is not part of a company team, the platoon leader must fulfill the role of the company team commander.

SITE SELECTION

Geographic locations of a tactical intercept/direction finding site depend on several factors. The frequency range and propagation characteristics of the enemy transmitters are important. For example, intercept/direction finding operations directed against VHF targets are usually located in a forward area. As previously stated, the intercept/direction finding equipment must be within LOS of the enemy's transmitting antennas. Operations directed against enemy transmitters operating in the HF spectrum can be located well to the rear of the FLOT.

The MI battalion S3, with the technical control and analysis element (TCAE), normally selects the general locations for MI battalion assets. The IEWSE coordinates and resolves the locations with the maneuver brigade staff. The platoon leader coordinates with local units as directed by the S3 and performs site reconnaissance for specific intercept/direction finding site locations. Generally, one primary and several alternate sites are selected. The first consideration in reconnaissance of a site is the terrain. The site must be accessible and relatively flat. The intercept/direction finding equipment must be able to be taken into and out of an area. This must be done in any type of weather and by more than one route when the command to "move out" is given. The site location should provide for rapid, disciplined movement. The movement would

be in conjunction with the result of rapid advances by friendly forces or retrograde movement to avoid capture and compromise or destruction by the enemy.

Advanced planning can simplify site reconnaissance and the selection of primary and alternate sites. A detailed map study of the entire area of operations is part of the planning process. An excellent aid is a modified area map with the contour lines color-coded by elevation. Color coding can be accomplished with felt-tip pens, grease pencils, or crayons. This information is extremely helpful when selecting a VHF site that operates by LOS. Color-coded changes in elevation and high ground areas adjacent to the selected site(s) are readily apparent.

The platoon leader or team chief should also conduct limited bearability tests during the reconnaissance. A bearability test determines how well the intercept/direction finding equipment can receive enemy signals of interest. When conducting the bearability test, the platoon leader must consider the friendly signal density. Heavy friendly signal activity may prevent successful intercept at an otherwise desirable site. There may also be times when a platoon leader or team chief will not have time to conduct a thorough or detailed reconnaissance trip. The combat unit may be involved in very rapid movements and the collection and jamming (C&J) platoon may be forced to move just as rapidly.

When this happens, it is crucial for the platoon leader or team chief to retain as much order and purpose to their movements as possible. The basics of site selection and defense preparation remain constant. They must be considered regardless of the posture of the supported command. If the platoon leader or team chief cannot obtain a proper site location in the given area, the MI battalion can assist and resolve the problem with the maneuver brigade staff through the IEWSE. The company team commander provides additional assistance as directed by the S3.

Once a site location has been identified, the platoon leader or team chief must determine the location of

adjacent units. Defensive measures must be coordinated with them. Fields of fire and protective positions must be identified, known, and understood by the platoon leader, team chief, and intercept/direction finding operators. The platoon leader or the team chief should draw up a site defense plan. The plan is placed into effect as soon as the team arrives on site. Additionally, the platoon leader or team chief should take the time to stake the area, indicating exactly where the equipment should be positioned. The platoon leader or team chief normally makes a rough site map and strip map for the equipment driver to follow.

BATTLEFIELD SURVIVAL

Because some intercept/DF systems may be located close to the FLOT and because of their unique antennas, their positions may be observed by enemy forward observers. Considering that attack on these systems by indirect fires is a probability, EW platoon leaders, team chiefs, and intercept/direction finding personnel should be knowledgeable of the enemy doctrine. This knowledge will enhance the survival of the intercept/direction finding systems and personnel.

Threat

The doctrine for the current threat to United States (US) forces calls for the employment of massive amounts of indirect fire. The majority of this fire will be preplanned and delivered as a coordinated part of the overall combat operation.

Artillery fires will be directed by observers operating from advance observation posts. The observers will be located in the forward lines of motorized rifle or tank units or main observation posts. The main observation post for a motorized rifle or tank battalion normally is within 500 to 1,000 meters of the FLOT. Forward observers are equipped with binoculars, range measuring equipment, and communications equipment. They can communicate directly with the artillery firing units. They can also detect targets out to 5 kilometers with their observation devices.

Not only can massed artillery fires against intercept/direction finding systems be called and delivered quickly and effectively, but attack helicopters could be used against intelligence gathering systems. Because of the helicopter's lethality and the skill of pilots in using terrain flight tactics, it is possible that enemy commanders will task these assets to attack US intercept/direction finding systems. US tactical intercept/DF systems must be properly camouflaged and positioned to survive against the enemy.

Camouflage

Camouflage can contribute to the survival of intercept/direction finding systems by reducing the enemy's ability to see the equipment. See is used here because the technology of sensors has advanced parallel with that of weapons. Seeing is no longer strictly a capability of the human eye. Enemy forces use sensors which can detect targets in the ultraviolet wavelength (shorter than visible). They can also detect targets in the broader near and far infrared and radar bands (wavelengths longer than visible). Intercept/DF systems have unique antenna systems, so camouflage techniques must be used to reduce the probability of detection by enemy observers. Sensors attempt to locate and identify equipment by means of radar image, visual image, or temperature change.

The US Army has implemented two basic camouflage concepts that provide protection from detection, either visually or electronically—

- Shape-disruptive painting.
- Lightweight camouflage screen system (LCSS).

Shape-disruptive painting is commonly called pattern painting or camouflage painting. This type of painting provides protection from image intensifying sensors such as the sniper scope and from cameras employing detection film.

LCSSs are usually referred to as garnished screens. They are manufactured as either radar scattering or radar transparent. The garnish of the radar-scattering screen contains minute fibers of stainless steel which inhibit the passage, reflection, and return of a radar signal. These screens are most effective against older, less sophisticated radar equipment. The radar transparent

version is made without these fibers and can be used without altering the effectiveness of the intercept/direction finding system. Obviously, the antennas of these systems cannot be camouflaged without degrading intercept or direction finding accuracy.

Positioning

Certain siting procedures can be followed which reduce the visibility of intercept/DF equipment even though the antennas of these systems cannot be camouflaged. Natural terrain features can be used to keep the antenna from standing out in a silhouette. The systems can be located in front of a hill or tree line, with the antenna below the top of the hill or trees. This reduces the visibility of the station and the antenna by obscuring their outline (Figure 5-8).



Figure 5-8. Reduced antenna visibility.

To a forward observer, the intercept/direction finding system profile would appear to be a continuation of the profile of the objects around it. Additionally, trees near the antenna can offer certain advantages as well as disadvantages. Foliage can be used to mask the antenna system from unwanted signals. That is, if the equipment is positioned so that the foliage behind and to each side of it extends higher than the antenna. However, foliage located between the antenna and the enemy transmitter antenna has an adverse effect on signal reception. Trees with heavy foliage absorb radio waves; leafy trees more than evergreens. Therefore, intercept/direction finding antennas should extend above the surface of the vegetation level when looking at the enemy transmitter antenna (Figure 5-9).

Redeployment

In a tactical situation, the intercept/direction finding systems must be redeployed frequently if they are to accomplish their mission and survive a hostile environment. This is due to the—

- LOS requirements for VHF intercept and DF. A significant change of the FLOT or the area of interest also requires redeployment.
- Area of interest of the supported division being larger than the area which can be covered by the intercept/direction finding systems. This requires frequent redeployment to adequately cover the desired area.

- Tactical intercept/direction finding systems requirement to stay within LOS of the target areas. This makes them susceptible to visual targeting and the possible detection of their communications equipment. Frequent redeployment reduces the chance of the enemy being able to effectively target and fire on them.

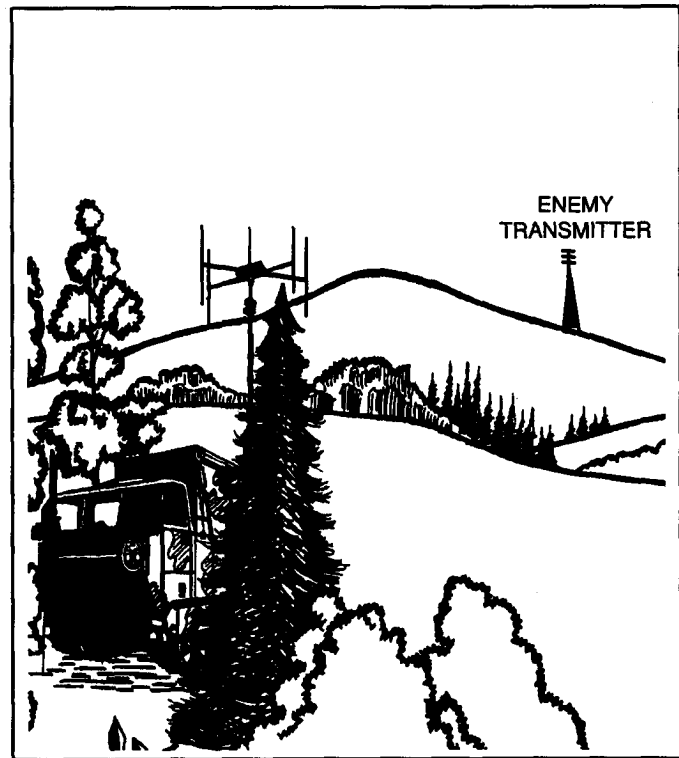


Figure 5-9. Looking at the enemy transmitter antenna.

AIRBORNE DIRECTION FINDING DEPLOYMENT

Fixed wing airborne direction finding systems are normally located at an airfield in the corps area. Heliborne systems operate from tactical sites with their parent aviation brigade units. Associated equipment is also located in close proximity to the airfield or tactical site.

ARDF aircraft requires flight patterns that may present the aircraft as targets to hostile forces. Depending upon

the terrain, altitude, and distance from the FLOT, the aircraft could be acquired by hostile radar or by the enemy. If the aircraft comes within operational range of the weapon system, they can be attacked by surface-to-air missiles or by airborne interceptors. Due to the classification of this book, survivability tactics will not be discussed.

CHAPTER 6

TASKING AND REPORTING

While strategic and tactical DF share similar basic fundamentals, they differ in other areas. For example, different equipment is used. Strategic direction finding is normally performed from either a fixed or a semifixed posture. Tactical direction finding operates from a mobile posture. There are also disparities between the distances from strategic and tactical DF sites to their net control stations.

Strategic sites are typically located several hundred kilometers from their NCS. Real estate of most allied countries (who host our strategic direction finding nets) is at a premium. Negotiation for land is not an ongoing

process. Barring a wartime situation, the likelihood of moving a strategic DF site from one location to another is extremely remote.

Tactical DF sites, normally located within 5 to 15 kilometers of the FLOT, are usually 10 to 15 kilometers from their NCS. Real estate for tactical groundbased DF systems must be coordinated with the supported combat commander. Due to the battlefield environment, frequent moves must be anticipated. Differences in equipment, distances from site to NCS, and deployment all affect tasking and reporting procedures.

COMMUNICATIONS

A prerequisite for direction finding tasking and reporting is rapid and secure communications. Strategic direction finding nets normally use secure telecommunications equipment for tasking and reporting, while tactical DF

tasking and reporting are normally accomplished using secure VHF radios. National Security Agency (NSA) approved manual encryption systems are available and are used to secure communications.

STRATEGIC TASKING

Strategic tasking is the assignment of a target or targets to the mission of a strategic DF net control station. Placing a target on the DF mission also includes the priority of the target. The priority determines which target will be tasked to the net in the event two targets of different priorities are active simultaneously. Generally, the mission of a strategic NCS fluctuates with the number of targets on assignment. Targets normally will be added and deleted on a daily basis. Specific information concerning mission assignment can be found in USSID 103.

The purpose of tasking is to determine the location, or in some cases direction only, of a transmitter from the NCS. Tasking may originate from a higher headquarters or it may be local. In either case, requests for direction finding must come to the NCS for action. A strategic

DF NCS is normally collocated with an intercept station. Intercept operators request bearings or the location of suspected or known enemy transmitters. Direction finding operators usually do not search the frequency spectrum for targets of interest. Rather, DF requests are received from intercept operators. The basic terminology commonly used at strategic and some tactical direction finding net control stations is listed in the glossary.

The following functions are presented in a chronological sequence to illustrate how strategic DF net control stations task their DF sites for bearing returns on target emitters:

- The intercept operator requests a bearing or the location on an enemy transmitter.

- The DF controller records the tip-off along with amplifying target information. This includes call signs, frequency, and type of traffic being passed, if any. This permits rapid identification of the target signal.
- The DF controller passes the target information to the DF flash operator.
- The DF flash operator notifies the DF sites of the target and provides tracking so they may obtain a bearing.

This sequence is repeated many times each day. In some strategic nets hundreds of targets are flashed to the DF net daily. Tasking the DF sites to provide a bearing on a transmitter does not complete the direction finding process. To satisfy the intercept operator's request for a location, each bearing from each DF site must be reported to the NCS so that analysis may be performed for reporting.

STRATEGIC REPORTING

Strategic reporting originates at each DF site. The reportable product is a bearing. After the DF site operator determines a bearing on the flashed target, it is returned to the NCS through the report net. The DF operator may be unable to obtain a bearing on some targets. This could be due to natural or man-made co-channel interference, signal strength (weak, fading signal), or target terminating its transmission before the DF operator could obtain a bearing. This would result in the DF site operator submitting a negative bearing return. (Negative bearing returns are defined in USSID 103.)

Regardless of the results obtained at the NCS (whether valid or negative), all bearing returns are collected on each flashed target and the bearings are plotted. Plotting is performed either by hand or computer. Detailed plotting and analysis is covered in Chapter 8. Once the bearings on a target have been plotted and a location has been determined, the location is reported to the requester. This is done to help identify the target as well as to preclude redundant DF requests. Higher headquarters and local policies dictate detailed strategic direction finding reports and reporting procedures. Additional information can be found in USSID 103.

TACTICAL TASKING

As previously mentioned, tactical direction finding operations are influenced by several factors. The most important are the—

- Tactical environment.
- Mission.

It is anticipated that the next war will be unpredictable and fast moving. Groundbased tactical DF equipment may have to be moved several times daily to maintain pace with the supported commander's forces.

The priority intelligence requirements (PIR) and information requirements (IR) of the supported division or corps commander will drive tactical DF tasking. Initial hostilities may find our forces with a limited enemy communications data base available for intelligence gathering operations. Building an adequate data base normally takes several days. The MI battalion TOC at division and the MI brigade TOC at corps

provide intercept and DF guidance during this initial period. The possibility of identified targets being placed on assignment for tactical DF is remote during the initial stages of hostilities.

In most situations, general guidance on target designated frequencies is provided to the intercept and DF operators. The frequencies are those known to be used by specific enemy elements such as artillery, armor, and rocket forces. The frequencies to be monitored for enemy activity depend on the supported commander's PIR and IR. Therefore, initial tactical direction finding efforts are dependent on intercept. A LOB is taken on all intercepted targets. If possible, a location of that transmitter is determined. Once a significant data base has been developed, the MI battalion TOC or MI brigade TOC will then provide more selective DF tasking to its tactical DF assets.

TACTICAL REPORTING

All direction finding bearings in a strategic net are reported immediately to the NCS. In tactical direction finding, the DF team, the platoon operations center, and the TCAE (collocated with the MI battalion TOC) are partners in the DF process.

The voice collection teams in support of division operations normally report LOBs as directed by the MI battalion TOC. As desired by the supported commander, the MI battalion TOC may direct that all bearings be reported immediately to the supported brigade.

Normally DF bearings taken by the voice collection teams are reported to the C&J platoon headquarters. Here the transcription and analysis team can perform quick plots if time permits and then, as directed, transmit the bearing results to the TCAE in the MI battalion TOC/supported brigade.

The noncommunications collection team reports all LOBs to the EW platoon headquarters which passes them to the MI battalion TOC. As directed by the supported commander, derived geographic locations are

then passed directly to the brigade or the fire support element.

Voice collection teams assigned to the operations platoon in support of corps report their bearings as directed by the brigade operation center. Normally the teams report their bearings to the transcription and analysis team of the operations platoon. Here, if time permits, they may be quickly plotted and then transmitted to the supported command or the MI brigade TOC. This, of course, will depend on the supported commander's desires. The ARDF systems and the noncommunications collection team in support of corps report their DF results directly to the MI brigade TOC.

At the MI battalion TOC or MI brigade TOC all bearings are consolidated, plotted, and, time permitting, integrated with other intelligence. Using groundbased DF and ARDF results, locations of enemy communications and noncommunications transmitters are determined. These locations are provided to the supported commander on a near real-time basis.

CHAPTER 7

ERRORS

To effectively plot direction finding bearings (or evaluate and report the most probable location of a target area) the person doing the plotting must know about direction finding errors. This information will influence their interpretation of the bearing intersection. Also, the supported commander should understand that due to the

influence of DF errors, enemy transmitter antennas cannot be pinpointed. However, a possible area can be identified where it is *highly probable* that the enemy transmitter antenna is located. This chapter describes common types of errors and their effect on direction finding.

SOURCE ERROR

Source error is a disruption of radio waves introduced at or near the enemy transmitter antenna. It can be caused by a specific type of directional antenna employed. It could also be caused by ground conditions at the antenna site which alter the normal radiation pattern of the antenna. If the DF equipment is farther than

15 kilometers from the transmitting antenna, the size of the source error is usually small. If the DF equipment is closer than 15 kilometers (as with the majority of our tactical DF systems), the source error will cause an inaccurate DF bearing.

PATH ERROR

Path error is caused by deviations of a radio wave from the great-circle path between the transmitting antenna and the DF system. This deviation is caused by the radio wave being absorbed, reflected, reradiated, refracted, or a combination of these factors. The more important sources of path error are—

- Scatter.
- Refraction.
- Reflection.
- Reradiation.

Scatter

In some instances, a small portion of the radio wave entering the ionosphere is scattered instead of being gradually bent and returned to earth. This scattered radio wave may be projected in any direction and is returned to the earth at random angles (Figure 7-1 and Figure 7-2, page 7-2).

The scatter phenomenon accounts for signals sporadically received in regions that are in a skip zone.

Error caused by scatter normally affects strategic direction finding sites but has little or no effect on tactical DF systems.

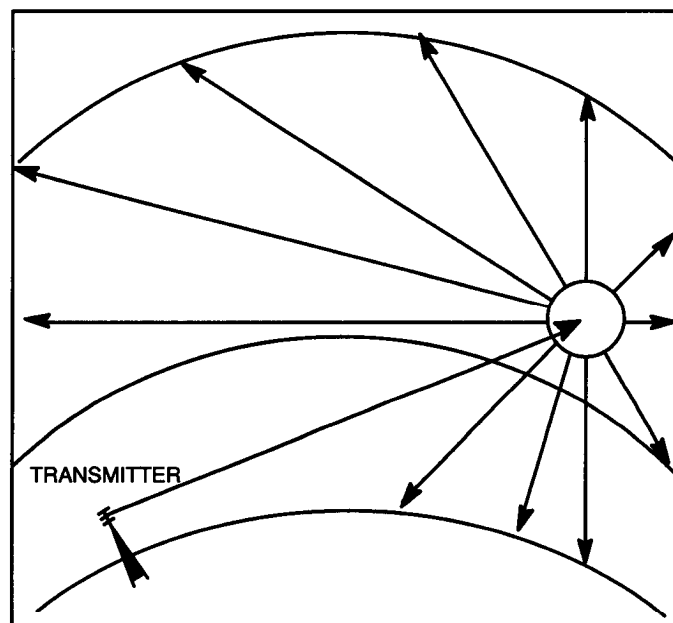


Figure 7-1. Short scatter.

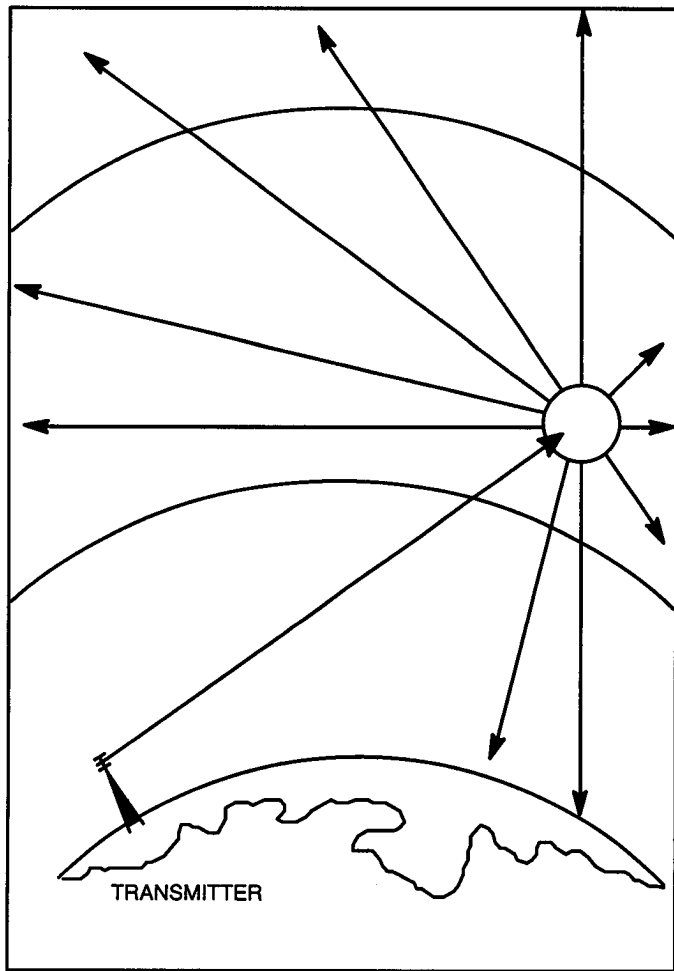


Figure 7-2. Long scatter.

Refraction

Radio waves (electromagnetic in character) are bent or refracted from their normal path when they pass from one medium to another. For example, the velocity of a radio wave over salt water is greater than its velocity over land or fresh water. As a result, when a radio wave crosses a coastline at an oblique angle, as illustrated in Figure 7-3, its direction is appreciably altered. Refraction error is particularly pronounced when either a DF site or the transmitting antenna is near the coast. This effect will also vary with the transmitted frequency.

Reflection

Reflection often causes incorrect DF bearings. A radio wave traveling over or close to cliffs, mountains, or tall buildings will in all probability be reflected (Figure 7-4).

The degree of reflection is immeasurable. It depends upon the obstacle and the frequency of the transmitted wave. Generally, DF errors are greatest from reflection when the reflecting mediums are located in the vicinity of either the transmitter or the DF equipment. Reflection error will affect both strategic and tactical direction finding systems.

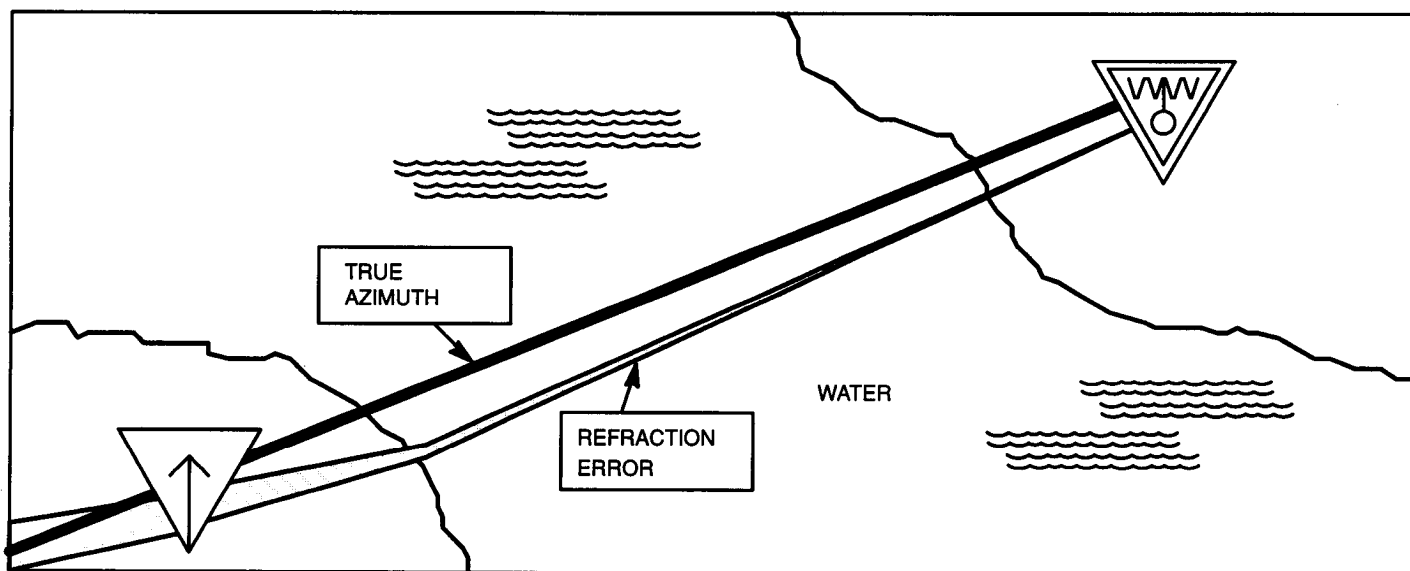


Figure 7-3. False azimuth indicated by refraction error.

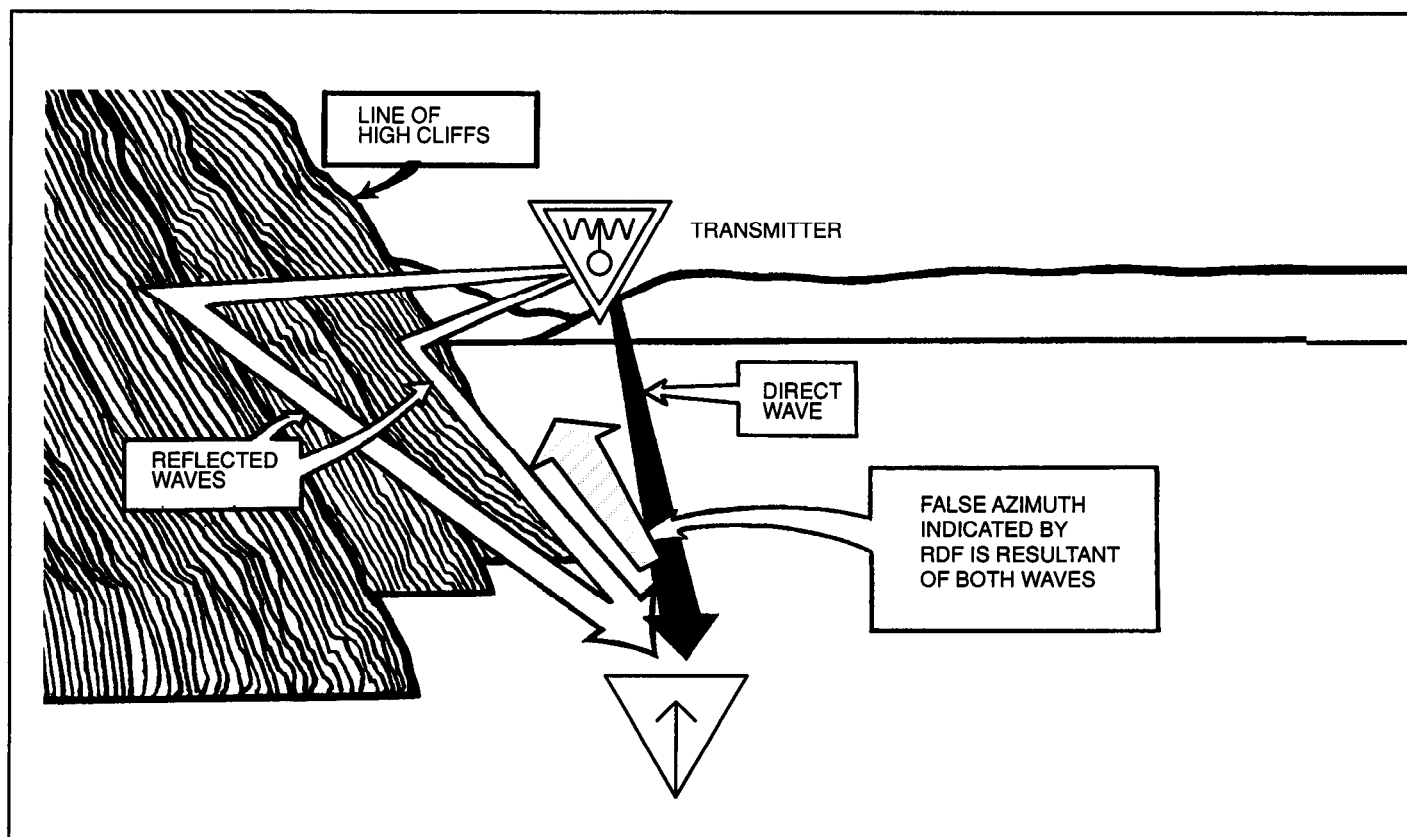


Figure 7-4. Reflection of a radio wave.

Reradiation

This effect occurs mainly because of the reradiation of the radio wave by metallic objects that are resonant at the frequency of the received wave. As a result of reradiation, the radio wave intercepted by the DF equipment may be abnormally polarized. An abnormally polarized signal makes the azimuth reading

or bearing very difficult to determine. Reradiation error normally occurs in the vicinity of the direction finding site. Therefore, at strategic and tactical DF sites it is important to adhere, if at all possible, to the site criteria guidelines presented in Chapter 5. Barbed wire, trucks, tanks, other combat vehicles, and metal buildings can cause reradiation error.

POLARIZATION ERROR

Polarization error occurs when an undesired component of a radio wave induces voltage in a DF antenna. This undesired voltage blurs the bearing and makes an azimuth reading difficult to determine. For example, a vertical loop or an Adcock direction finding antenna (Figure 7-5, page 7-4) is designed to receive vertically polarized radio waves.

If the received wave is abnormally or randomly polarized (contains vertically and horizontally polarized

components), the voltage induced by the two components may combine. The azimuth reading on the signal will be difficult, if not impossible, to determine. The effect of polarization error depends upon the ability of the DF antenna (loop or Adcock) to discriminate between the desired component (vertically polarized wave) and the undesired component (horizontally polarized wave) of the received signal. Polarization error is common in most DF operations.

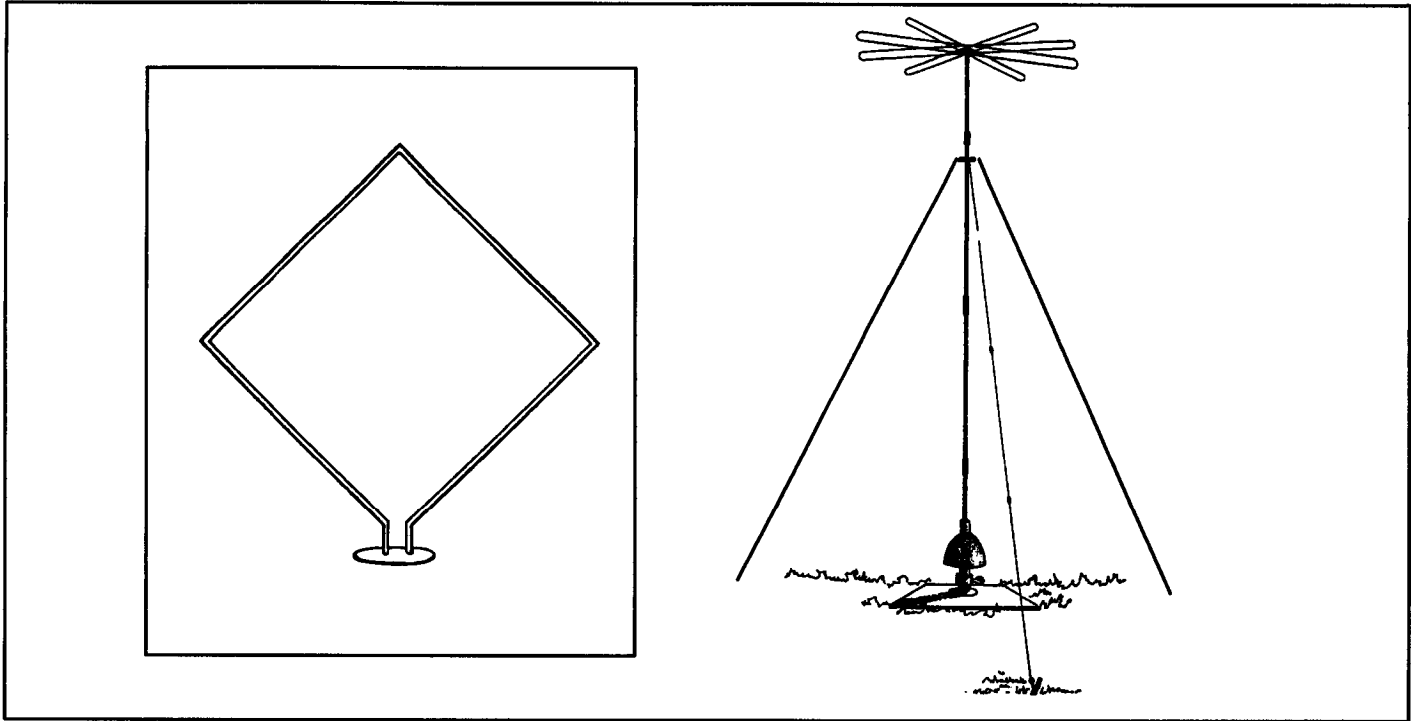


Figure 7-5. Vertical loop and Adcock antennas.

SITE ERROR

Site error occurs in the immediate vicinity of the direction finding site. Site error may be a result of one factor or a combination of several factors. Orientation of the DF system's antennas is extremely important in obtaining maximum DF accuracy. Whenever a direction finding site is setup in a new location, its antennas must be precisely oriented to a known reference point. This produces an accurate measurement of the arrival angle of the wave front. Without this accuracy, the plotting of the reported bearings is of no value. (See Chapter 6.)

Radio waves can be reflected from their original paths by various obstacles. The DF equipment will measure the actual angle of arrival at the DF antenna. Therefore, the DF antenna should be positioned where the wave path is least susceptible to outside influences. The DF equipment then will give the most accurate representation of the true direction of radio wave travel.

Obstructions in the near vicinity of strategic and tactical direction finding sites contribute to site error. The closer the obstruction is to the DF site, the greater its adverse

effect on the accuracy of the site's bearings. Errors caused by obstructions in the vicinity of the site can be eliminated by careful site selection.

Although in many cases the best available site location is far from ideal, definite measures for improving the site from a technical standpoint can be taken. For example, strategic DF sites (which are not substantially flat for at least 90 meters from the DF antennas) can be leveled off with a bulldozer or grader. If it is impossible to level the entire area for 360 degrees coverage, at least those areas within the azimuth arc of primary interest should be flattened. Natural objects such as trees and low vegetation should be cut down or uprooted. Vehicles and personnel not actually engaged in operations at the DF site should be kept away from the antenna system. Tactical DF site improvement is difficult because many compromises must be made for the sake of survivability. However, general site selection guidelines were provided in Chapter 5. They should be followed with discretion when selecting a tactical DF site.

INSTRUMENT ERROR

Instrument error is introduced by the DF equipment itself. Groundbased strategic and tactical DF equipment is designed to perform with a system bearing accuracy of plus or minus 2 degrees. It should be understood, however, that this accuracy is provided within an electronics laboratory where the equipment is unaffected by environmental or human effects. This accuracy provides a point of comparison and should never be used to predict the accuracy of target acquisition.

Normally, DF instrument error is dependent upon the general condition and adjustment of the equipment. A lack of a good maintenance program may also introduce instrument error. The DF operators can contribute to this problem if they perform poor first-echelon equipment maintenance. Various calibrations and adjustments must

be performed at regular intervals. These procedures are described in associated DF equipment technical manuals. They improve equipment performance and result in more accurate DF results.

Daily bearings on known transmitters (check bearings) should be taken at strategic DF sites. These transmitters are commonly called *check targets*. They are used to show if the accuracy or calibration of the DF equipment is acceptable. The check targets must represent the entire frequency spectrum and distances required in DF operation. Any appreciable deviation of the DF bearings (from the known bearing or the bearings normally obtained on a check target) should be investigated immediately.

OPERATOR ERROR

Operator errors are reduced to a minimum when operators have received sufficient training and experience. Newly assigned direction finding personnel must be trained by their supervisor. The DF training program is a supervisor responsibility. Although the service school responsible for training operators provides excellent instruction in many areas, there is no substitute for on-the-job training. Additionally, DF operators must be alert at all times when operating the

equipment. For example, DF operators are required to take bearings on many signals that are weak or fading. Through training, the operator learns to obtain an azimuth on the weak or fading signal when it appears strongest or most stable. Under adverse conditions, an efficient DF operator normally takes several readings and then determines the azimuth by averaging the readings to a mean bearing.

CHAPTER 8

PLOTING AND ANALYSIS

PROCEDURES AND TECHNIQUES

A DF plotter and analyst have an important job. They plot and evaluate the locations of transmitting antennas. This result is then used to determine enemy intentions or uncover enemy locations. At a strategic site, the DF analyst's product may reveal a mobilization for war or a sudden shift in defensive posture. The analyst acts as a catalyst by drawing on the raw data from the field and processing it into a viable product for battlefield commanders or national consumers.

This chapter provides reference to a multitude of procedures and techniques for plotting and analysis. Yet, as the word analysis implies, there is an element of human judgment involved in the process. Choosing the correct technique for the situation and applying the procedures correctly is imperative for mission accomplishment. Without sound plotting and analysis, the best DF equipment in the world would be useless.

DEVELOPING MAP PROJECTIONS

A map that is used for DF plotting and analysis is a graphic representation of a portion of the earth's surface. Although drawn to scale, no map is absolutely accurate since it represents the earth as a plane or flat surface. No portion of the earth's surface can be spread out into a flat plane without some *stretching* or *tearing*. This is illustrated by attempting to flatten either the cap of an orange peel or a portion of a hollow rubber ball. The outer portion must be stretched or torn before the central part will flatten. However, there are some surfaces which can be spread out in a flat surface without stretching or tearing. These are called developable surfaces. Surfaces which cannot be spread out in a flat surface, such as a sphere, are called nondevelopable surfaces.

Three well-known developable surfaces are the cone, plane, and cylinder. If a paper cone is cut from its base to the apex, the conical surface can be spread out in a flat surface without tearing or stretching (Figure 8-1). If such a cone is flattened, any line or curve drawn on it will have exactly the same length as before. In the same manner, if a cylindrical surface is cut from base to base, the whole surface can be rolled out into a plane or a

rectangle (Figure 8-2). In this case, there is no stretching or tearing of any part of its surface.

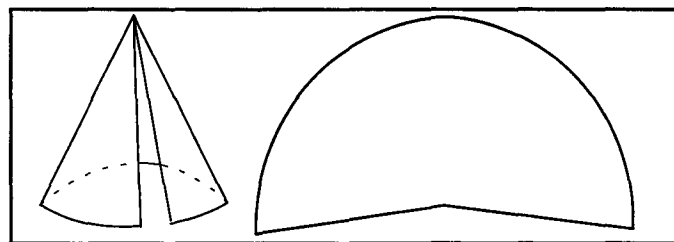


Figure 8-1. Conical surface.

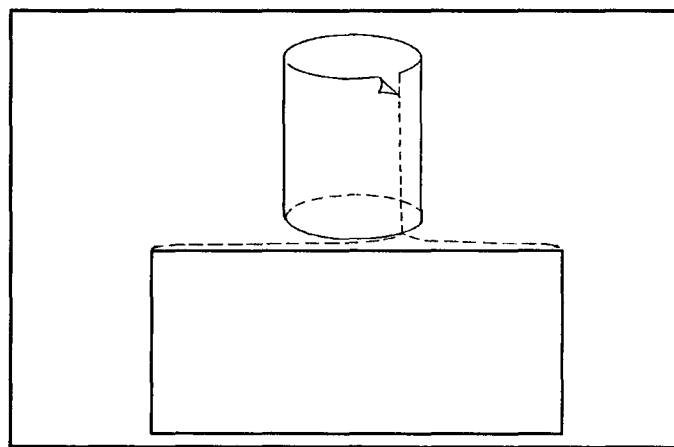


Figure 8-2. Cylindrical surface.

Since the spheroidal shape of the earth cannot be represented on a plane without distortion, a compromise must be made to obtain the most practical features for a specific use. Many different types of map projections have been devised. Each has special merits for its intended use, while compromising other features. The map projections used for direction finding plotting must be a type that a straight line, from a given point, will indicate the true azimuth. Two map projections commonly used for DF plotting and analysis are—

- Universal transverse mercator projection.
- Gnomonic projection.

Universal Transverse Mercator Projection

The universal transverse mercator projection is produced through the use of a cylinder. To project means literally to *throw forward*. A map projection is the network of coordinates picked off the globe and thrown upon a surface. A mercator projection is a mathematical projection very similar to what would be formed by projecting lines from the center of the earth to a cylinder. The cylinder fits around the earth and touches at the equator (Figure 8-3).

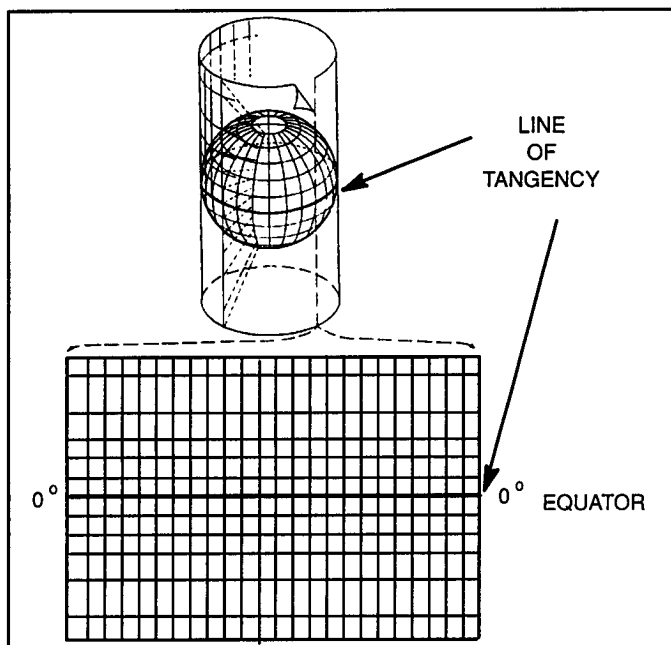


Figure 8-3. Mercator projection.

If the image of the earth could be projected against the cylinder and fixed there, the cylinder could be cut open and laid out flat. This would result in a sheet map that is comparatively accurate in the equatorial region. However, it is more and more distorted as the polar regions are approached. The line of tangency of the mercator projection is a horizontal line—in this example, the Equator. Turning the cylinder across its former horizontal line—that is, transverseing it—results in the transverse mercator projection (Figure 8-4).

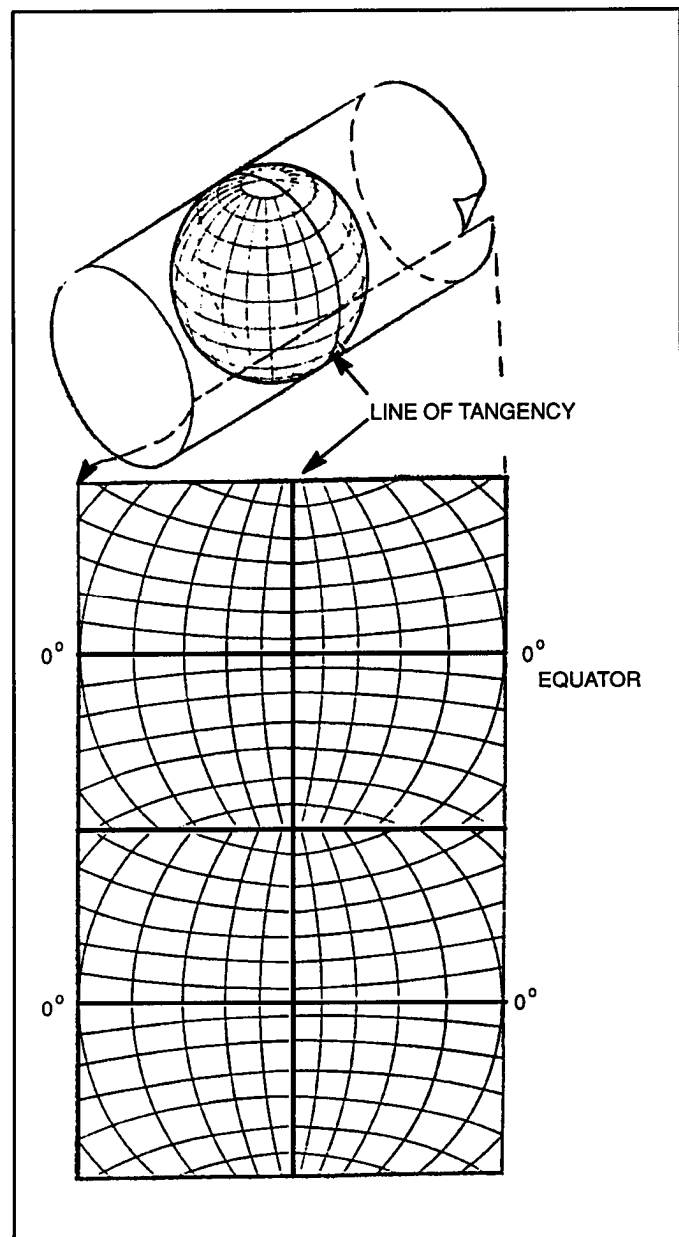


Figure 8-4. Transverse mercator projection.

The significant difference is that the transverse mercator projection uses a longitudinal or a vertical line as its line of tangency in place of a horizontal line (Equator) used in a mercator projection. By choosing several lines of longitude or meridians as lines of tangency, several transverse mercator projections can be constructed. When laid side by side, the entire land mass of the earth is mapped in north-south sections with a minimum of distortion.

The universal transverse mercator projection is the most common map projection used for tactical military purposes. It can be easily oriented for combat situations and readily used with a compass to find a true azimuth from any given point on the map. The UTM system makes it possible to plot from point to point using a straight line called a rhumb line. Advantages of using a universal transverse mercator projection for direction finding plotting are—

- Individual map sheets of the same scale may be joined to form a map of a larger area.
- Direction finding plotting and analysis within 200 miles on either side of the line of tangency can be accomplished with an ordinary protractor (true compass rose).
- There are no north-south plotting limitations.

Gnomonic Projection

A gnomonic projection of the earth is derived by projecting the surface of the globe, from its center, upon a planar surface. The gnomonic projection is the most commonly used map projection system for long-range strategic direction finding plotting and analysis. It is

particularly useful when plotting across great expanses of ocean. This projection method represents all great circles as straight lines. This is the projection's chief merit. This is important in DF plotting and analysis because the shortest route between two points, a straight line, is always a portion of the arc of a great circle. As a general rule, radio waves travel in great circle routes. The limitation of producing a gnomonic projection is that only a quarter of the globe, or 90 degrees, can be projected. Distortion beyond 90 degrees becomes severe and renders the projection useless for direction finding purposes.

Advantages of using a gnomonic projection for strategic direction finding plotting and analysis are as follows:

- Radio waves will appear as straight lines throughout the projection. There are no distance limitations imposed; only that of the area encompassed by the map.
- Strategic direction finding sites need not be located within the boundaries of the projection. As long as you know the latitude and longitude of the DF site, you can compute for the points where the site's bearing will enter and exit the projection.

Due to the amount of distortion in this type of projection, protractor plotting is limited to those areas located within 4 degrees of the point of tangency. Most strategic sites are established on a baseline located outside of the 4 degree area around the point of tangency. Bearings from these sites (as well as those sites located off the chart) require mathematical correction to compensate for map distortion. Mathematical correction methods are presented in Chapter 9.

PLOTTING

The following terms are commonly used in strategic and tactical plotting facilities:

- Line of bearing.
- Cut.
- Fix.

A line of bearing is the angular measurement of a radio wave in degrees from a given reference (true, magnetic, or grid north) (Figure 8-5).

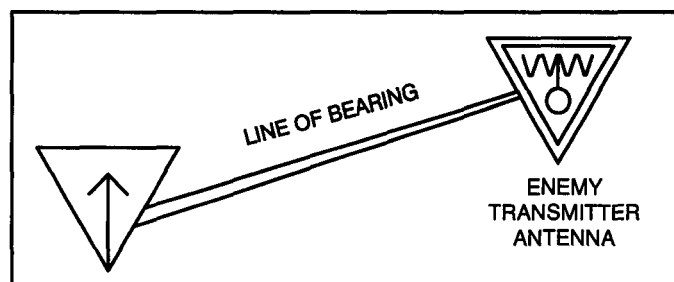


Figure 8-5. Line of bearing.

A cut is the point of intersection of two DF LOBs (Figure 8-6).

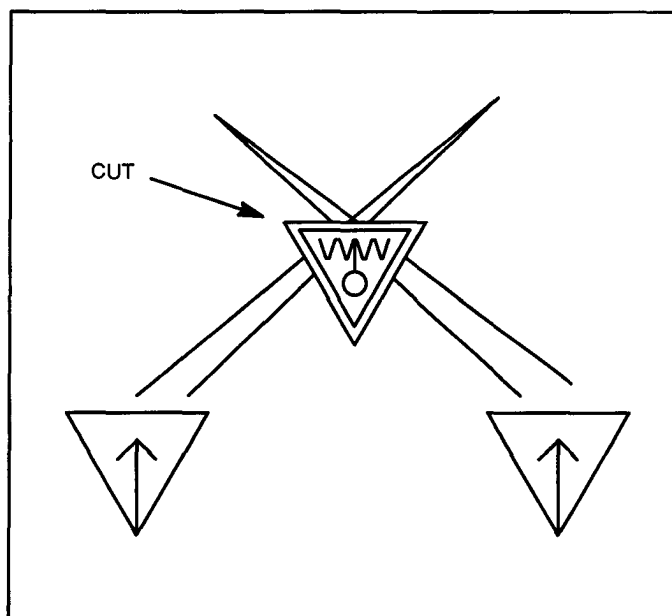


Figure 8-6. Cut.

A fix represents three or more DF plotted bearings that intersect (Figure 8-7).

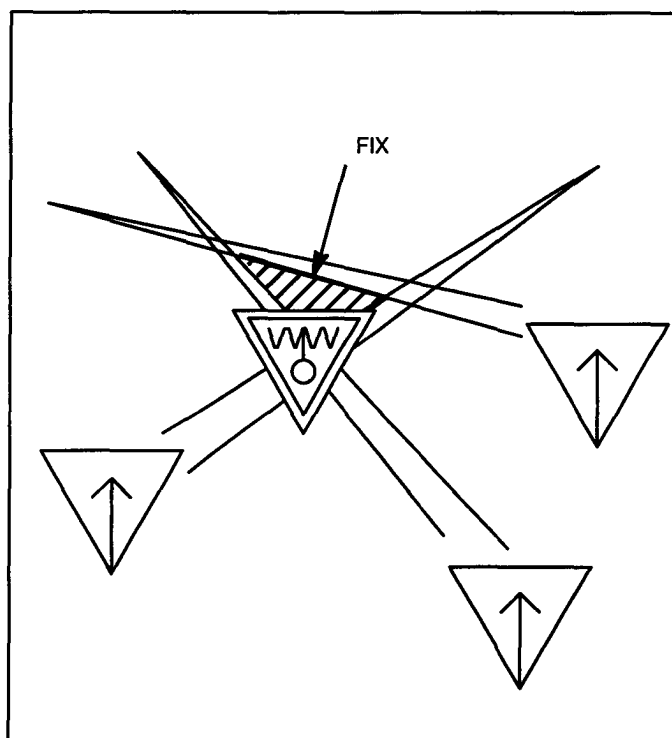


Figure 8-7. Fix.

Plotting a Line of Bearing

The simplest method of plotting a bearing is with a protractor and straightedge. Point A in Figure 8-8 represents the known location (by grid coordinates) of a DF station. This is entered as a tick mark (') on the map or overlay. In the example, the index of the protractor is placed to coincide with point A and is accurately aligned along the north-south grid lines by using dividers or parallel rulers. Either true or grid alignment may be used. Magnetic orientation is not used. While grid and true north reference lines are corrected throughout the map, magnetic declination is accurate only at the center of the map. As the scale of the UTM increases so does the inaccuracy of the magnetic orientation. Plotting at distances greater than 200 miles along an east-west axis will require a gnomonic projection. This is because the UTM becomes too distorted. (This includes combining several UTM maps.) The bearing taken by the DF station is measured in degrees from grid north and is indicated by another tick mark at the appropriate degree on the protractor. The protractor is removed and the straightedge aligned along two tick marks. The bearing is then plotted by drawing a line along the straightedge from the station location through the degree tick marks. Extend the line a sufficient length into the target area. The enemy's transmitting antenna is probably located along this line.

NOTE: The protractor may be aligned with a grid or true north, depending on DF equipment or reporting criteria.

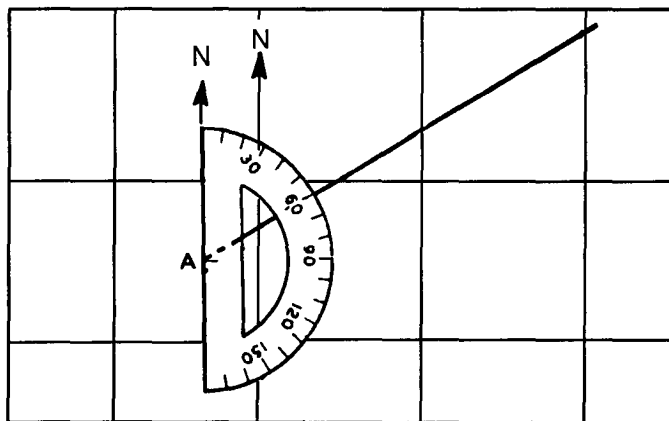


Figure 8-8. Plotting a bearing.

Plotting a Cut

Using the method outlined above, the bearing from a second DF station is plotted. The intersection of the two plotted bearings is identified as a DF cut (Figure 8-9).

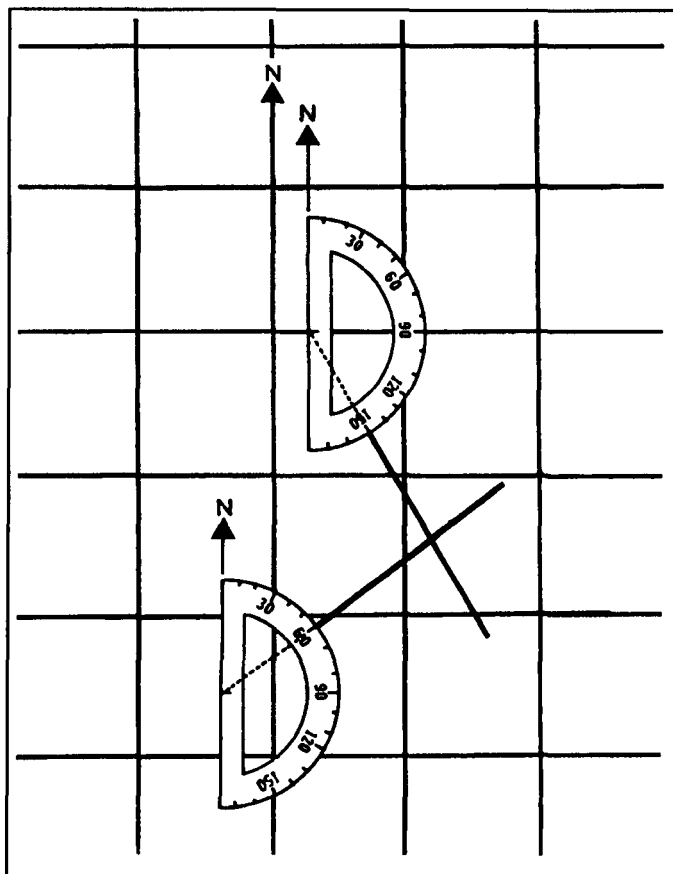


Figure 8-9. Plotting a cut.

Plotting a Fix

If three or more direction finding sites are arranged along a baseline, the protractor may still be used. As illustrated in Figure 8-10, DF sites A, B, and C are plotted and have reported bearings of 60, 90, and 130 degrees respectively.

Again, the protractor and straightedge may be used to successively plot the bearings of each DF site at its map location. The lines may be extended to form a small triangle. They may join at a point if the fix is perfect. Figure 8-11 illustrates a perfect fix. However, a perfect fix is extremely rare and suspect.

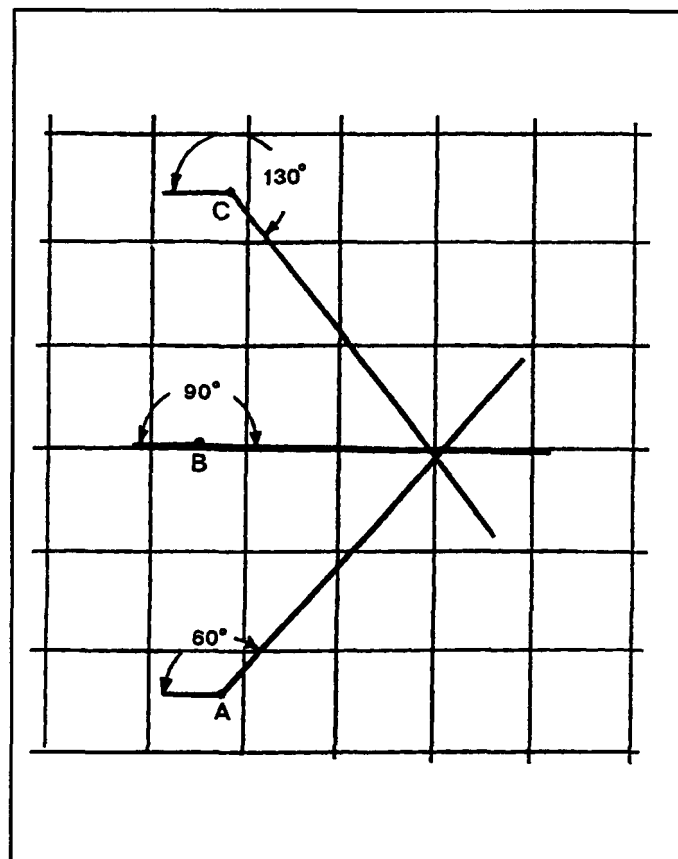


Figure 8-10. Plotting a DF fix.

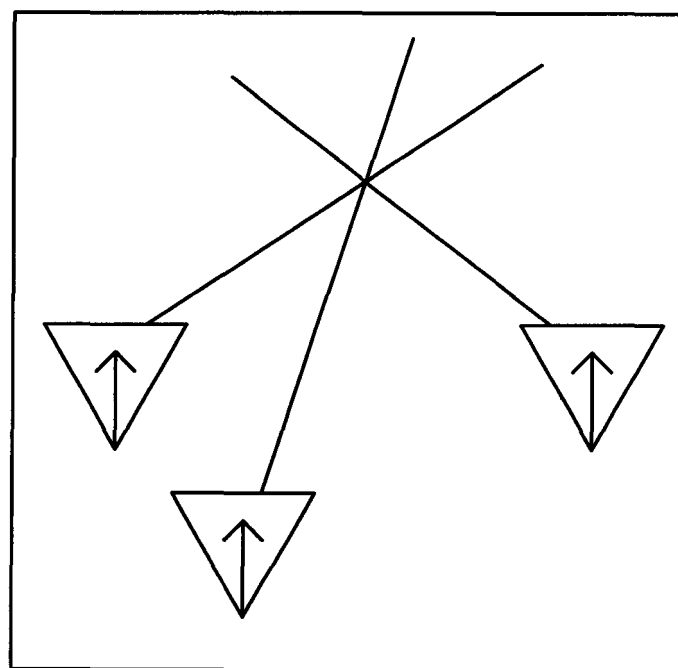


Figure 8-11. A perfect fix.

Map Size

The size and scale of the maps used in DF plotting and analysis depend on—

- Whether the direction finding effort is strategic or tactical.
- Range of the bearings to be plotted.
- Length of the baseline.

As previously mentioned, a gnomonic map projection is normally used for strategic plotting and analysis. The universal transverse mercator is used for tactical plotting and analysis. The range of the bearings or the distance from the DF sites to the target area obviously will affect the size of the plotting map. In a tactical situation, perhaps more than one map sheet may have to be joined with another to plot the DF sites' bearings. This is caused by the DF baseline being too long for a single map sheet. It could also be caused by the target area being too deep for a single map sheet. An ideal DF baseline should be the same length as the expected depth of the target area. Using a gnomonic map for strategic plotting, it is possible to have DF sites located off the map and still be able to plot their bearings. However, in

a tactical situation this is not possible. The map size has to allow for all sites to be located on the map projection.

Plotting and Analysis Centers

The plotting procedures described above, while completely valid in terms of accuracy, are somewhat slow and laborious. A DF plotter/analyst would find it difficult to plot all the DF bearing returns using a protractor and straightedge because of the following:

- Advancement of direction finding state of the art.
- Greater number of bearings reported by individual DF sites.

Accordingly, DF plotting and analysis centers with in-depth analysis capabilities have been established. In these centers, plotting boards are used. They have the DF sites LOBs represented by strings which may be pulled out and lined on calibrated map-edge scales. The plotter/analyst simply notes the DF site, the reported bearing, and the calibrated edge scale for the particular reporting site. When the string is pulled out and aligned along the reported bearing on the appropriate map-edge scale, the bearing is plotted. Additional DF sites are plotted in the same manner. The intersection of bearings determines the most probable target location.

FIX ANALYSIS

Plotting and fix analysis is the practice of determining the best place to put the target coordinates and from that point, an area in which the target may conceivably be located.

Thus far, ideal plotting and analysis conditions have been discussed. In the practical application of DF plotting and analysis, the returned bearings are carefully evaluated by the plotter/analyst. They determine the most correct or most probable location or best point estimate (BPE) of the target of interest. A perfect fix, with three or more bearings intersecting at an exact grid location, is rare. When plotting and analyzing, the plotter/analyst has many factors which must be considered.

The process of plotting and fix analysis is substantially influenced by several human factors in the evaluation of

the DF site's bearings. As the plotter/analyst's experience builds and reported fix locations are confirmed by enemy contacts or other reliable means, the plotter/analyst will concede increasing credibility to one DF site over another. In other words, each DF site develops a *track record*. A change of DF operators at a particular DF site can also influence the analytical process. In spite of the standard assignment of reliability indicators, manual plotting and fix analysis is still greatly influenced by these human factors.

The DF plotter/analyst must also be aware of DF equipment characteristics. For example, the design characteristics of some direction finding equipment are plus or minus 2 degrees. (Different DF equipment has different accuracy ratios.) This means that a bearing return is not a straight line. It is an ever-widening,

fanlike path. There is a high probability the transmitting antenna is located within this path. The center line of path A (Figure 8-12) has the highest probability that the target is located somewhere along this line. As the distance from the center line increases towards B, the target location probability decreases.

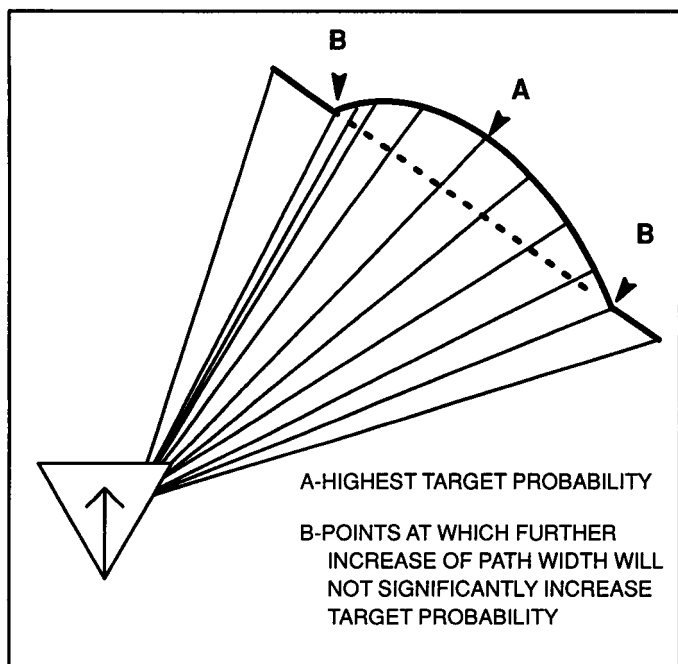


Figure 8-12. Bearing path.

Path width, or B, is determined during the design and testing of DF equipment. It is normally expressed as an angle, in degrees, based on mathematical calculations. Therefore, to determine the specific target area it is necessary for the bearings from two or more DF sites to intersect. A DF plotter must keep in mind that when the bearings intersect (Figure 8-13) the probable target area along each path is limited. It is limited to the width of the intersecting bearing paths at the point of intersection.

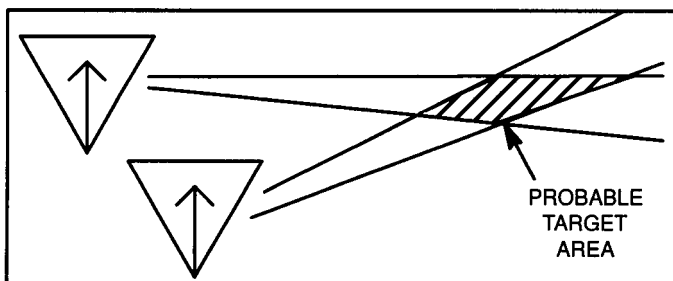


Figure 8-13. Intersecting bearing paths.

The direction finding fixes discussed in this chapter have all been *perfect* with all site bearings intersecting at an exact grid location. Of course, such a fix seldom occurs because of the inherent errors in DF operations. Significant contributions to direction finding inaccuracies are the—

- Continually changing electromagnetic environment of each DF site.
- Inherent equipment error.
- Operator error.
- Natural and man-made objects around the transmitting/receiving antennas.

Cut

It is possible to evaluate a cut. Obviously, such a plot is not normally used in DF reporting unless an extreme, high priority condition exists. However, the cut is frequently used at strategic DF sites for general distance or area observations and optimum antenna selection for intercept. A cut is not practical to obtain a fix point; therefore, an area must be determined in this analysis. Such a fix area is illustrated in Figure 8-14. If each individual bearing is represented by a fan-shaped figure centered about the bearing, it may be stated that there is a probability that the true bearing lies within this fan. This is called a fan bearing.

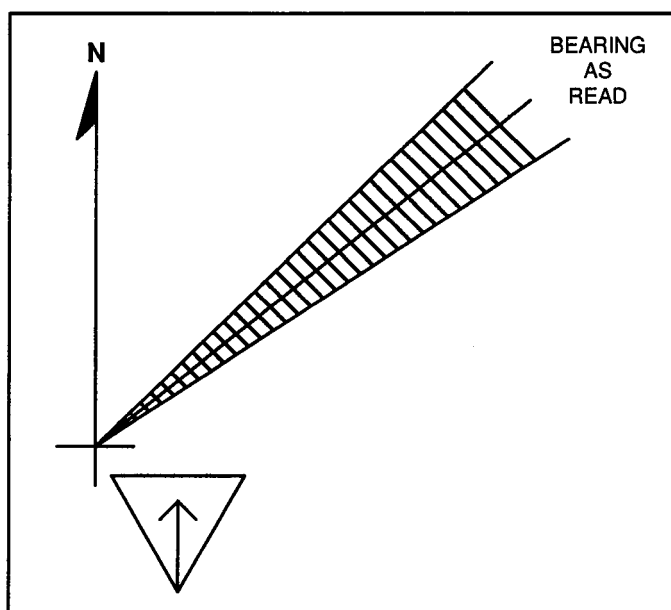


Figure 8-14. Fan bearing.

A two-station fan fix is shown in Figure 8-15. If each fan represents the limits within which there is a probability of 50 percent (1 to 1 chance) that the bearing lies there, then the cross-hatched portion represents the area in which there is a probability of 25 percent (1 to 3 chances) that the transmitter antenna lies there. Each site has its own standard deviation (SD). This is a measurement of the reliability of the sites' bearings based on the historical data base. (For more information on SD, see Chapter 9). By increasing the size of each bearing fan to the width of the DF site's SD, it may be estimated that the probability is 90 percent (9 to 1 chance) that each bearing lies within the fan, and that there is a probability of 81 percent (4 to 1 chance) that the transmitter antenna lies within the cross-hatched area. If the site SD is not available, expand the bearings to a total fan width of 10 degrees.

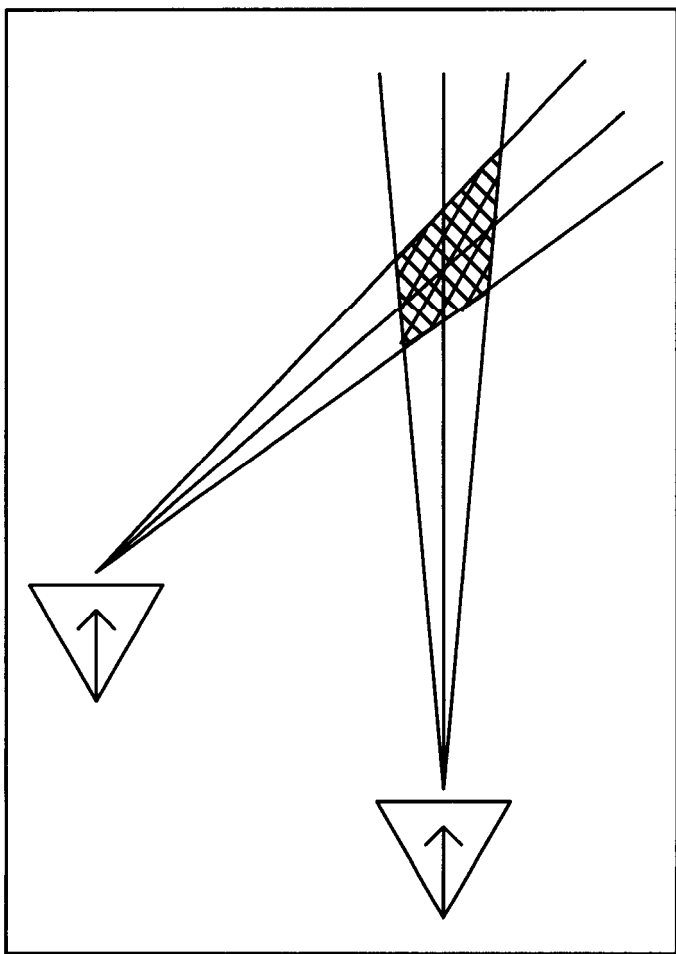


Figure 8-15. Two-station fan fix.

Extension of the two-station fan fix into fixes of three or more stations becomes very complicated and leads to ambiguous results. Even for a two-station fix, the area frequently becomes excessively large for any reasonable probability. However, by more refined mathematical considerations involving the theory of probability and the theory of least squares, it is possible to determine the size, shape, and location of a minimum area with a stated probability that the transmitter antenna lies within it. This applies to any number of DF sites involved.

Three-Station Fix

When plotting three bearings, one of three possible events occurs—

- No-fix situation, where a fix solution is not feasible.
- Perfect fix situation, where all three bearings intersect at a single point.
- Error triangle situation, where an area of probability is formed.

No Fix

As illustrated in Figure 8-16, a fix solution is not always feasible. This occurs more frequently with three-station plots than with plots of four or more stations. In many situations, the analyst will be cautious and will choose to report a no fix rather than risk reporting an erroneous location. For example, a triangle that encompasses a 3 by 3 grid-square area would not help to locate a mechanized infantry company. Due to the relatively low priority and speed of the unit, the plotter or analyst would consider the target information too inaccurate for use. However, if the same triangle was applied to a company transporting nuclear missiles, the target information (regardless of its accuracy) may be deemed of such importance that it justifies an inexact fix report. In such situations, use of each site's SD is helpful. Not all tactical sites will have these statistics available, but for those that do, such statistics will prove useful during analysis. Figure 8-17 illustrates how a large triangle can be reduced using SD. The bearing lines for the two sites are adjusted by applying twice the SD of each site. This produces a workable triangle for analysis.

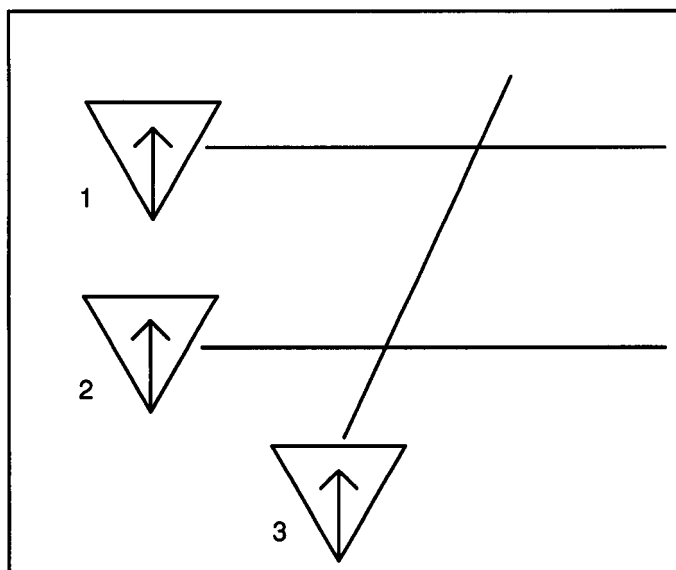


Figure 8-16. No fix.

Perfect Fix

Figure 8-18, page 8-10 illustrates a perfect fix situation. However, this plot could misdirect analysis. Such a fix does not guarantee that the point of intersection represents the exact location of the target transmitter antenna. Conceivably such a fix could be obtained if two or more bearings were in error.

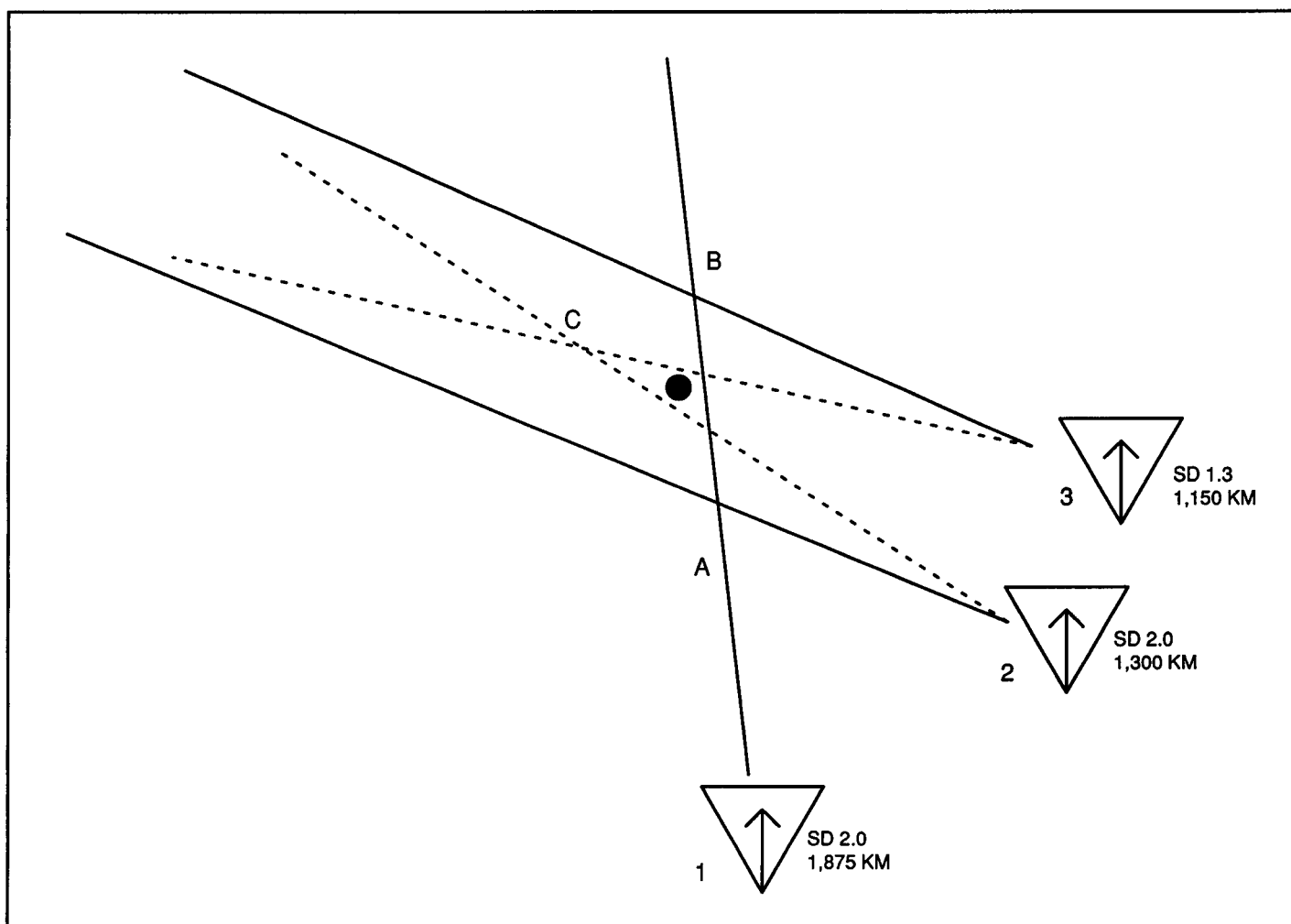


Figure 8-17. Using site SD to reduce triangle.

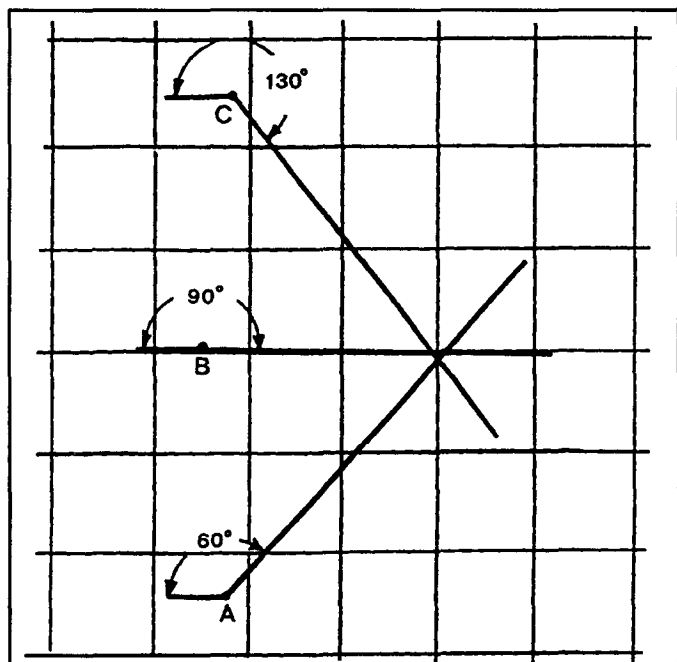


Figure 8-18. Perfect fix.

Error Triangle

This is the more usual type of three station bearing intersection found in DF analysis. It is sometimes called *triangulation* because the bearings intersect to form some type of triangle. There are many different methods employed to analyze a triangle to determine a fix point. These are—

- Bisection of the medians of a triangle.
- Bisection of the angles of a triangle.
- Steiner point.
- Visual inspection.
- Modified visual inspection.

NOTE: Strategic DF nets will most often use the visual inspection method. Prior to using this method, however, a reliable direction finding site data base must be established. The exceptions are those DF networks that use computers to do the plotting. As our dependence on automation grows, the computer assumes many of the duties once accomplished by a competent plotter. However

equipment and power outages necessitate that every DF plotting facility train DF plotters how to manually plot using one of these methods.

Bisection of the Medians of a Triangle. To evaluate a fix using this method, the plotter simply draws a line from the midpoint of each median to the opposing angle. As illustrated in Figure 8-19, a line is plotted from the midpoint of line BC to angle A. Another line is plotted or drawn from the midpoint of line AC to angle B. The last line is drawn from the midpoint of line AB to angle C. The error triangle solution or probable target emitter location is the point where the three lines intersect or A'. This method should only be used on a case by case basis, where the immediacy of a report precludes the use of visual inspection or the construction of a steiner template.

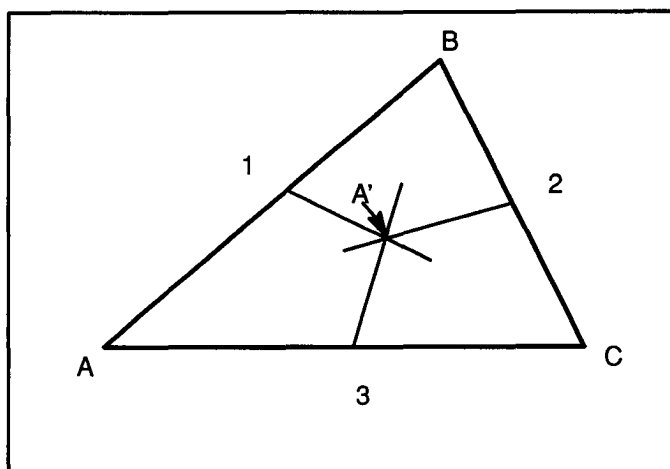


Figure 8-19. Bisecting the medians.

Bisection of the Angles of a Triangle. Determining the error triangle solution by bisecting the angles of the triangle is illustrated in Figure 8-20. The plotter must first determine the degree of each angle. Then each angle must be bisected. In Figure 8-20 the bisecting lines are drawn from angle A to point 1, from angle B to point 2, and from angle C to point 3. The solution (B') is the point where the three lines intersect. Conditions mentioned in the use of the bisecting the medians method must also be applied to the use of this method.

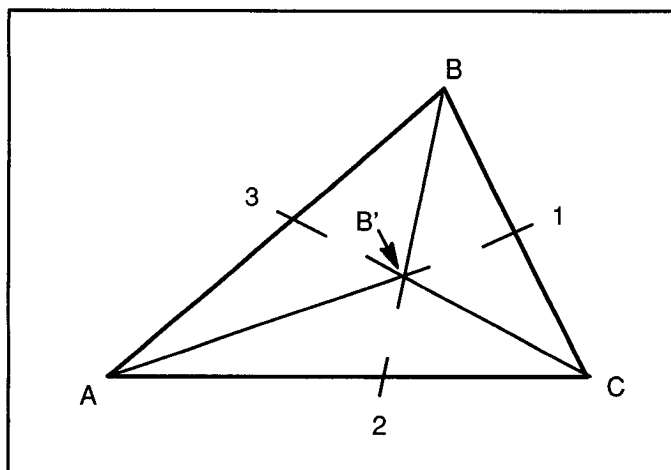


Figure 8-20. Bisecting the angles.

Steiner Point. The steiner point is the point at which the sum of its distances from the vertices of the triangle is at a minimum. The steiner point method is only used when speed and ease of analysis are required. The steiner point is located at the intersection of three lines drawn from the vertices of the triangle and making an angle of 120 degrees from each other. In an obtuse triangle having an angle of 120 degrees or greater, the vertex of that angle is the steiner point (Figure 8-21). For the remaining triangles having angles less than 120 degrees, the most practical method to place the steiner point is by constructing a simple equilateral template from transparent material.

To construct a template, draw a circle on a sheet of clear plastic. Ensure the circle is large enough in size to encircle your error triangles. Make a small hole in the exact center of the circle. Etch three lines from the center hole, exactly 120 degrees apart, to the outer circumference of the circle, thus trisecting the circle. Another method of template construction is to etch an appropriately sized equilateral triangle on a sheet of clear plastic. Then etch lines on the template from the vertices and punch a hole at the intersection. Either method of construction is equally accurate. When the template is completed, place the template over the error triangle formed after the three bearings are plotted. Rotate the template and align it until each of the 120 degree etched lines passes through each vertex of the triangle.

Mark the location (C') as illustrated in Figure 8-21. Place a pencil through the hole in the center of the template and mark this area. This is the steiner point or fix point. This mark is reported by grid coordinates as the most probable target emitter location.

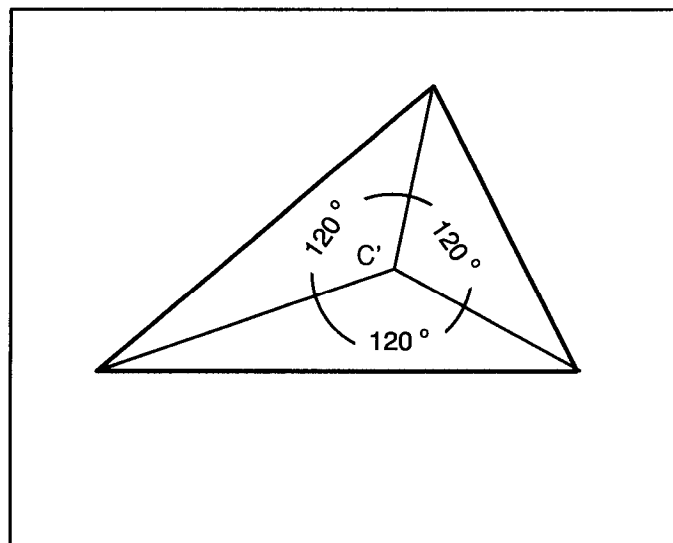


Figure 8-21. Steiner point.

Visual Inspection. Essentially, the visual inspection method involves analyzing all available data affecting the fix area and selecting a fix point based on all factors. The visual inspection method is the only analytical method approved by the United States Army Intelligence and Security Command (INSCOM) for use in strategic and EAC manual plotting analysis. This is the only method which applies an analysis of all five factors affecting DF capabilities. All of the factors may not be used in an analysis. The number of factors used depends on the unit mission, standing operating procedures (SOP), and equipment. Although this method consumes more time than other methods, it is the most accurate method available. The factors are as follows:

- **Angles of bearing intersection.** More consideration is given to bearings that intersect at or near right angles. This is because bearings at a 90 degree angle of intersection result in a smaller linear deviation than any other angle of intersection. As an immoderate example, we will use the range of strategic DF (Figure 8-22, page 8-12). A bearing intersection at a distance of about 375 nautical miles (Nm) from two DF sites with an angular deviation of about plus or

Bearing classification. Some DF site operators measure the confidence factor (also known as degree of certainty or validity) in bearing accuracy. This measurement can be indicated by confirmed and doubtful tags on bearing returns. The confidence factor is produced by the DF operator. A confirmed bearing return indicates that the operator is sure the correct target has been acquired and the bearing is stable. A doubtful return signifies that either the operator is not sure it has been acquired or the bearing was not stable, or both. The DF plotter/analyst would trust a confirmed or high number bearing return more than a doubtful or low numbered bearing return.

Known reliability of the DF site based upon past performance. Standard deviation measures the reliability of each DF site. Systematic error (SE) measures the accuracy of each DF site. Together, these statistics provide a qualitative measure of each DF site's potential (in comparison to the other DF sites) by reflecting the average accuracy of the site's DF results. A site with a low SD should normally be more reliable than a site with a high SD. Therefore, more consideration is generally given to sites with lower SDs. If a DF site usually has a low SE, and then suddenly the SE fluctuates considerably in either a positive or negative direction, the bearings from that site must be considered less reliable until the SE is stabilized.

Modified Visual Inspection. Due to the high mobility of most tactical DF systems, some of the factors used in the visual inspection method cannot be analyzed. In tactical analysis, angles of intersection, terrain, and bearing classification were the most important factors.

Figure 8-22. Bearing linear deviation.

Therefore, the plotting method is modified to reflect tactical considerations. The modified visual inspection method is dependent on five factors as follows:

- **Angles of bearing intersection.** Naturally, tactical systems have less range, but the linear deviations are still appreciable.
- **Bearing classification.** In some tactical systems the bearing confidence factor (or bearing validity) may be measured by a numbering system (or LOB quality factor). The higher the quality factor, the better the bearing return. This factor is dependent on the amount of integration time of the DF system, the amount of time the target stays active, and the amount of bearing deviation in the bearing calculations. The numbers may also indicate the number of samplings (shots) taken to obtain a mean bearing.
- **Terrain features between the DF site and the target, at the target area, and around the DF site.** With the exception of Quasi-Doppler and ARDF systems, terrain analysis is a very important factor when using tactical systems. Terrain features have a much more important role in tactical analysis. There are two parts to this analysis—the terrain between the DF site and the target and the terrain at the probable fix area.

NOTE: Terrain features between the DF site and the target, such as mountains and lakes, can deter the arrival angle of the bearing at the DF site. Therefore, the plotter/analyst would not place as much confidence in such a bearing return. Using the modified visual inspection method to produce the most probable target location, the DF plotter/analyst must examine the map in detail. When determining a fix point, the plotter/analyst must use common sense. The plotter/analyst must study the geographic qualities of the fix that have been produced. Should the indicated location be in the middle of a large lake, it is unlikely that the transmitter antenna has been accurately located. If the most probable fix location is atop an inaccessible crag or butte, the DF plotter/analyst must once again apply a little logic. The terrain features adjacent to the

indicated location must again be examined. Transmitter antennas that usually serve a command or headquarters are likely to be located where such troop units would logically be stationed or encamped. Camps, trails, roads, water supplies, and similar terrain features must be evaluated when formulating the most probable fix location.

- **Site statistics.** Because of the tactical site's mobility, site statistics may not be available. With the exception of some EAC DF systems, site statistics are not a major factor in tactical DF plotting and analysis.
- **Distance.** Distance has a role in tactical plotting and analysis but, due to the short to medium range of targets, distance may not have as much of an affect as it does in strategic plotting and analysis.

Modified Techniques

Methods similar to those explained in the *three-station fix* section of this chapter can be used for fixes of four or more bearings. Only visual and modified visual inspection analysis implements the myriad of factors involved in the fix. All other methods are deficient in the area. For intersections resulting in an *error quadrilateral* (a polygon of four sides), the following methods could theoretically be used—

- Intersection of the two diagonals of the error quadrilateral.
- Intersection of the two diagonals of the quadrilateral formed by the steiner points of each of the four triangles of the error quadrilateral.
- Steiner point of the triangle formed by the three steiner points of the three triangles of the error quadrilateral.

Obviously, the preceding methods are time consuming and difficult. The visual and modified visual inspection method are easier, faster, and more accurate. The analytical technique is the same as described in the *three-station fix* section of this chapter. The following illustrations (Figures 8-23 through 8-34, pages 8-14 through 8-17) show the complete visual inspection process.

Visual Inspection Process

Angle of bearing intersection. In Figure 8-23, site 2 and site 3 bearings intersect at a near right angle. This factor would influence the analyst to place the target plot in that corner of the fix area.

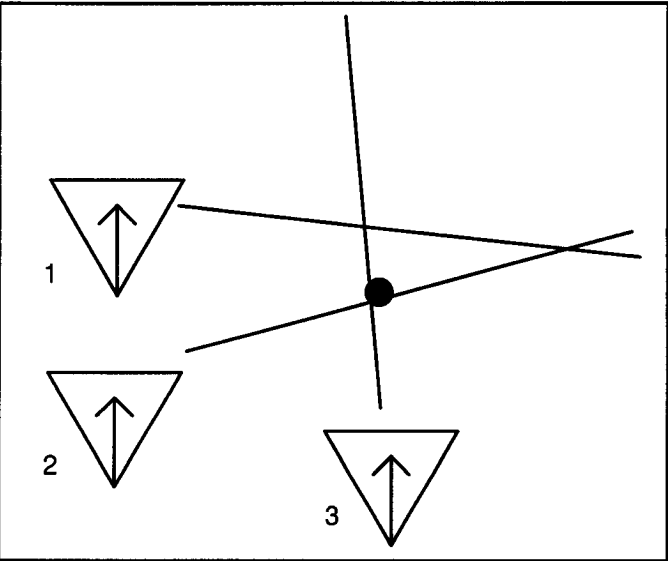


Figure 8-23. Angle of bearing intersection.

Distance factor. Distance is the influencing factor in Figure 8-24. Due to the distance of site 1 from the target, the analyst places more emphasis on the intersection of bearings from sites 2 and 3.

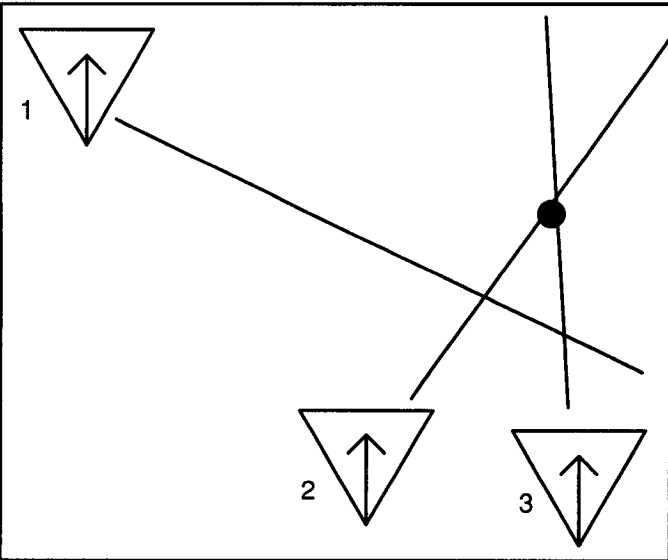


Figure 8-24. Distance factor.

Bearing classification. In Figure 8-25, site 1 has a *doubtful* bearing return. The analyst would put more emphasis on the *certain* bearing returns of sites 2 and 3. The analyst places the fix point closer to the intersection of the certain bearing returns.

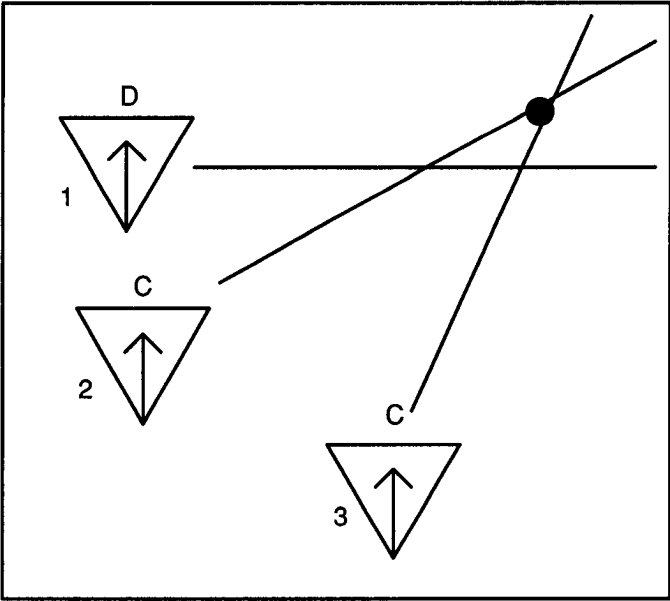


Figure 8-25. Bearing classification.

Equilateral triangle. When bearings form an equilateral triangle (as shown on Figure 8-26) and no other factors affect the analysis, the analyst would place the fix point in the exact center of the triangle.

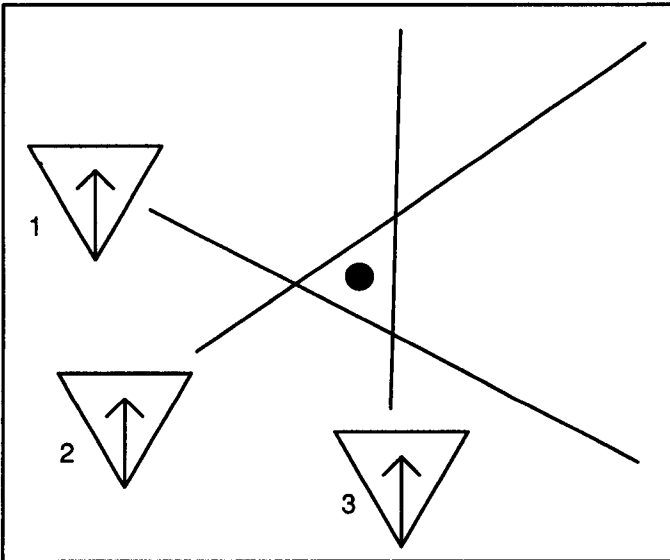


Figure 8-26. Equilateral triangle.

Site reliability. In Figure 8-27, site 3 has a high standard deviation. In this case, the analyst would place more emphasis on the bearing intersection of the lower SD sites (sites 1 and 2). The analyst would move the fix point to that part of the fix area.

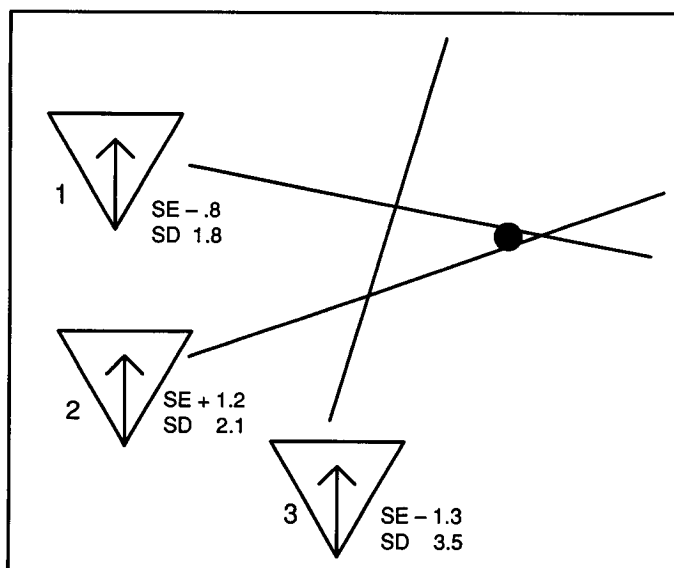


Figure 8-27. Site reliability.

Terrain. In Figure 8-28, a mountain interferes with the accuracy of site 1. Therefore, the analyst would place more emphasis on the intersection of bearings from sites 2 and 3, placing the fix point in that part of the fix area.

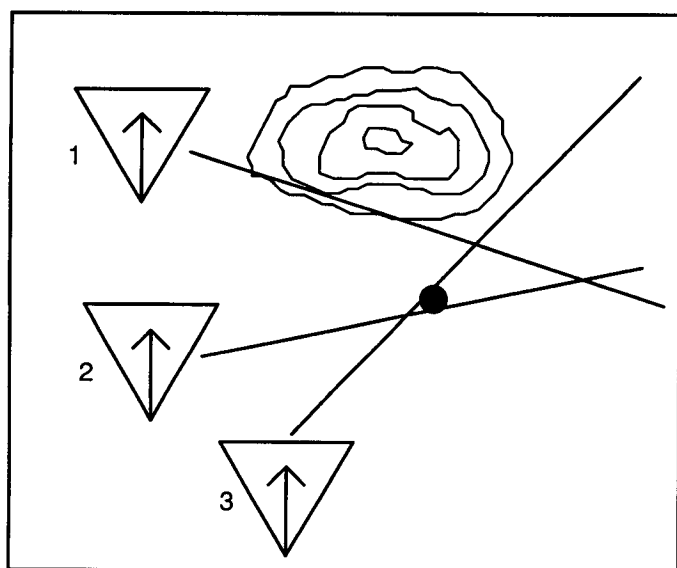


Figure 8-28. Terrain factor.

Up to this point, the fix analyst examples have been based on simple three site (station) triangulation with only one factor affecting analysis. In most DF nets, four or more sites are used to enhance productivity and accuracy. Numerous factors affecting analysis may be encountered in the selection of a single target's fix point within the probable fix area.

In example A (Figure 8-29), the best angle is formed by sites 2 and 4 (the most reliable sites). Site 1 has a doubtful bearing return and has a high SD. The bearing return from site 3 is probably not accurate because of the mountain. Considering these factors, the DF analyst would select a fix point closer to the bearing intersection of sites 2 and 4.

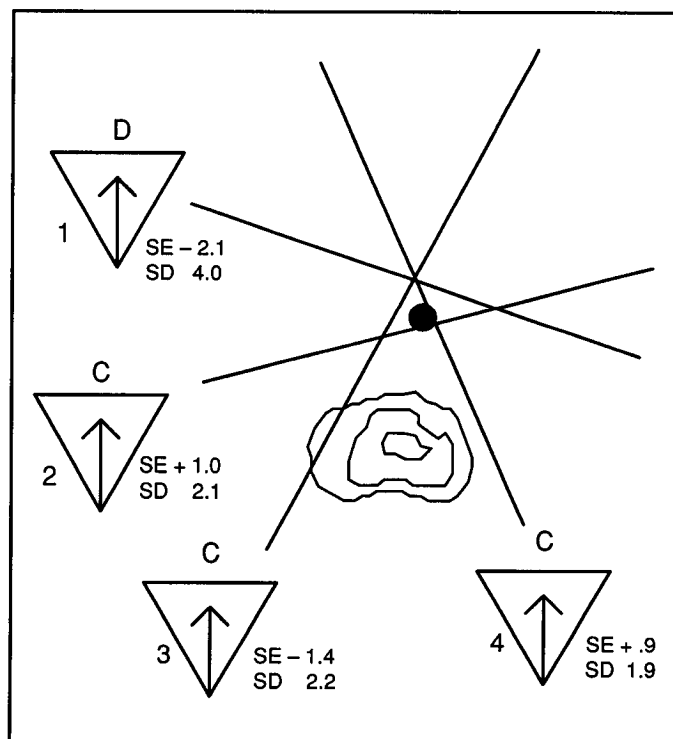


Figure 8-29. Example A.

In example B (Figure 8-30, page 8-16), although sites 1 and 3 form the best angle of intersection and are the most reliable sites, placing the fix point in that part of the fix area would put the target in the lake. Since the target is known to be a groundbased entity, the analyst would move the fix point onto the land.

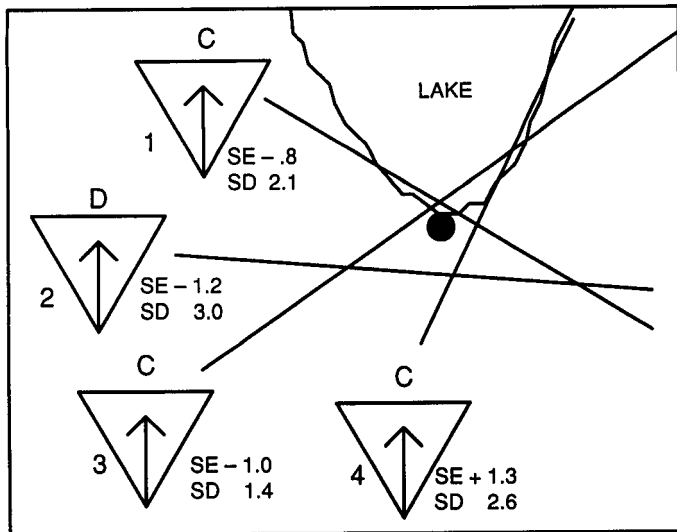


Figure 8-30. Example B.

In example C (Figure 8-31), site 2 has a doubtful bearing return and site 3 has a high SD. The best angle of bearing intersection is formed by sites 1 and 4. The analyst would place more emphasis on the best angle; plotting the target closer to the best angle of bearing intersection.

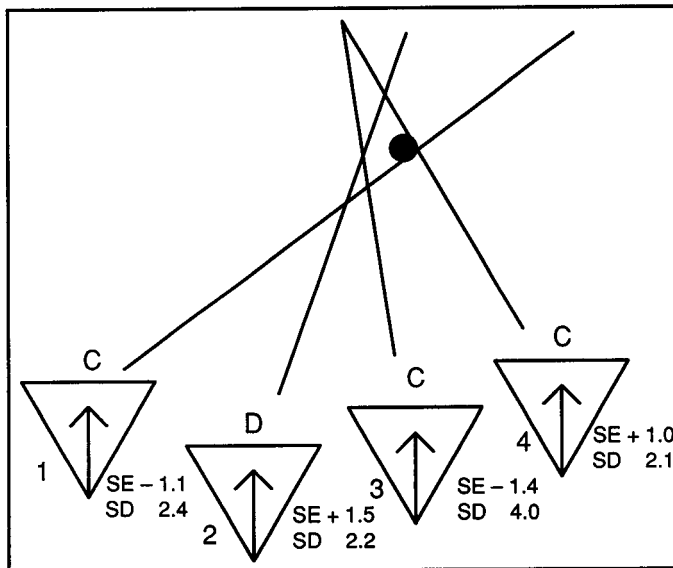


Figure 8-31. Example C.

In example D (Figure 8-32), site 4 has a doubtful bearing return and the highest SD. The analyst would rely more on the bearing returns of the other sites. Since sites 1 and 3 form the best angle of bearing intersection, the fix point would be plotted in that part of the fix area.

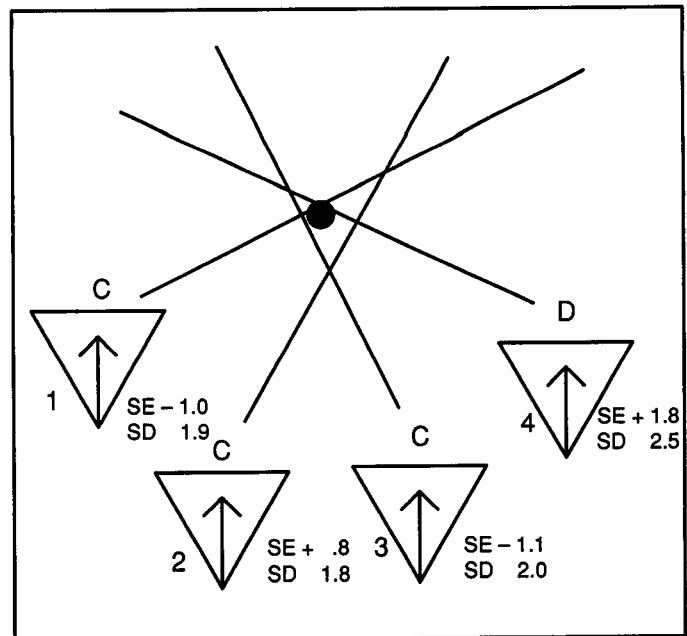


Figure 8-32. Example D.

In example E (Figure 8-33), site 1 has a doubtful bearing return and a high SD. Site 5 is near a mountain, which could cause some distortion. The best angle of bearing intersection is formed by the remaining three reliable sites. Since the analyst would not totally disregard the bearing returns from sites 1 and 5, the plot would be placed as illustrated to allow for their influence.

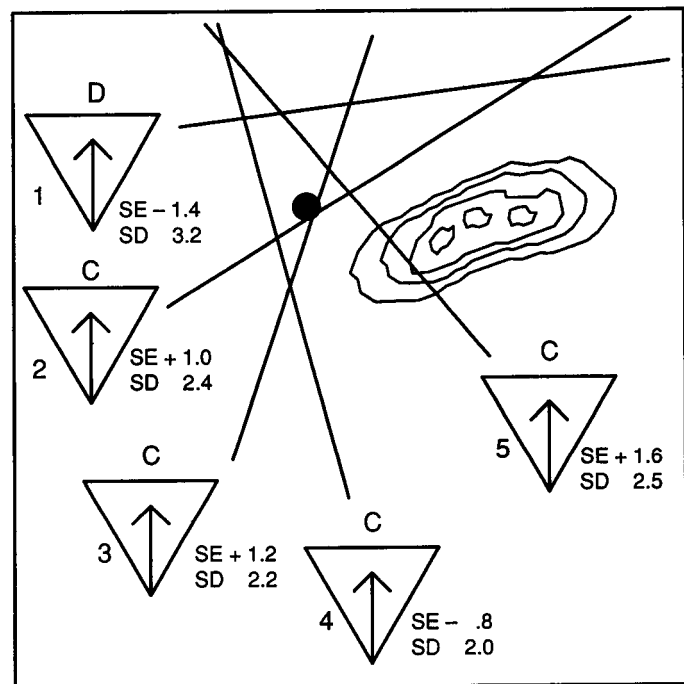


Figure 8-33. Example E.

In example F (Figure 8-34), the best angle of bearing intersection is formed by sites 2 and 4. Based on their SD, these sites are also the most reliable. Sites 1 and 3 have doubtful bearing returns. However, as indicated by the plotted bearing returns from the other sites, site 1 and site 3 bearings are within the area of probability and should be given some consideration. The analyst would shift the fix point from the best angle of intersection in order to include some influence from these sites.

In example G (Figure 8-35), a bow tie is created in the plot. The fix point is shifted toward the bearing generated by site 1 because of the reliability. Applying the secondary bearing (adding or subtracting twice the SD) to the configuration would move bearing 2 toward the area indicated by the other bearings. If twice the SD of site 2 had not entered the indicated fix region, the bearing would have been discarded as a wild bearing.

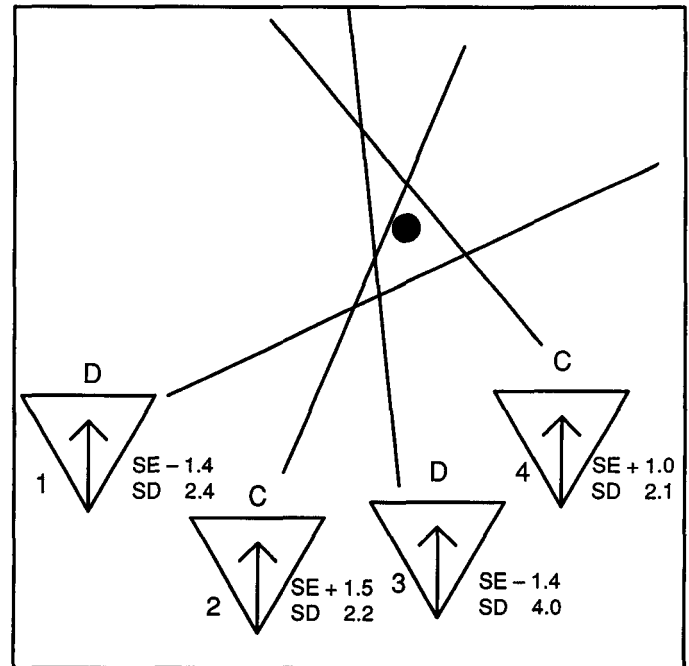


Figure 8-34. Example F.

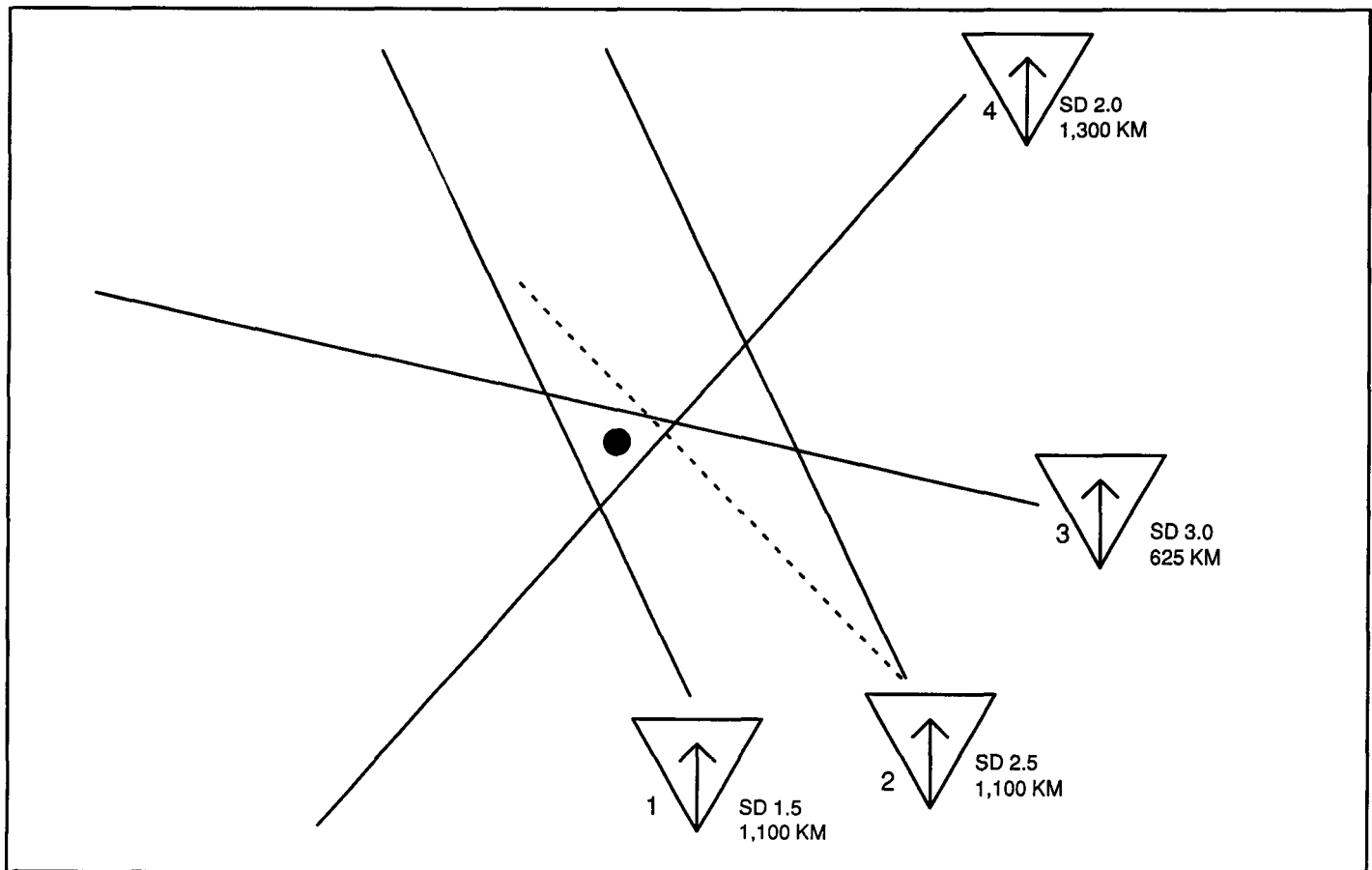


Figure 8-35. Example G.

Single Station Locator Plotting and Analysis

To plot the bearings from the SSL site, ordinary border coordinate or corrected compass rose (CCR) methods can be used (see Chapter 9). To plot the range from the SSL site, a series of semicircular or circular Range patterns can be placed equidistant from the SSL site that equate to various distances from the site (Figure 8-36). The increments of circular Ranges used depends on the operating distance of the particular SSL system.

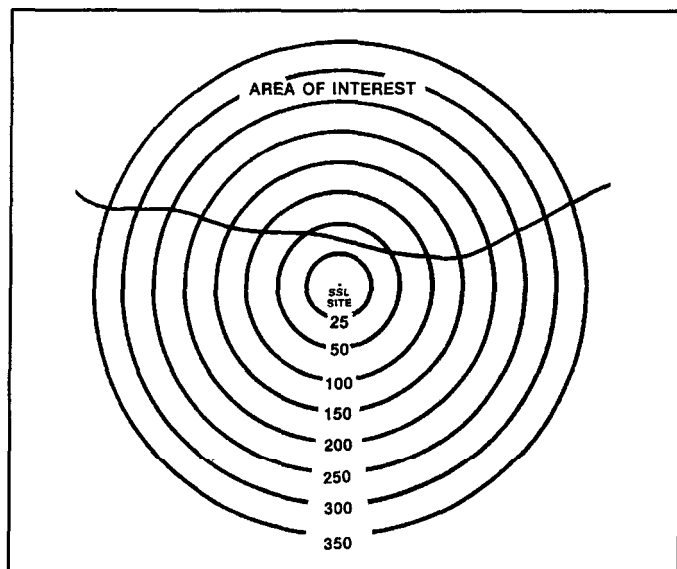


Figure 8-36. Circular Range pattern.

The analytical processing of SSL data is radically different from conventional methods of analysis. The SSL system relies on the propagation of skywaves by the ionosphere. Frequently, this reliance produces *multipath* solutions (Figure 8-37). This means the arriving electromagnetic waves have been propagated at two or more stratum (altitudes) of the ionosphere. The analyst must determine which elevation (or range) is correct. Due to this characteristic of the SSL system, it is important that the DF analyst maintain a close liaison with the traffic analysis (TA) element.

The actual fix point is determined by locating the range along the line of bearing (Figure 8-38). The coordinates are read in the same manner as previously discussed for tactical or strategic analysis.

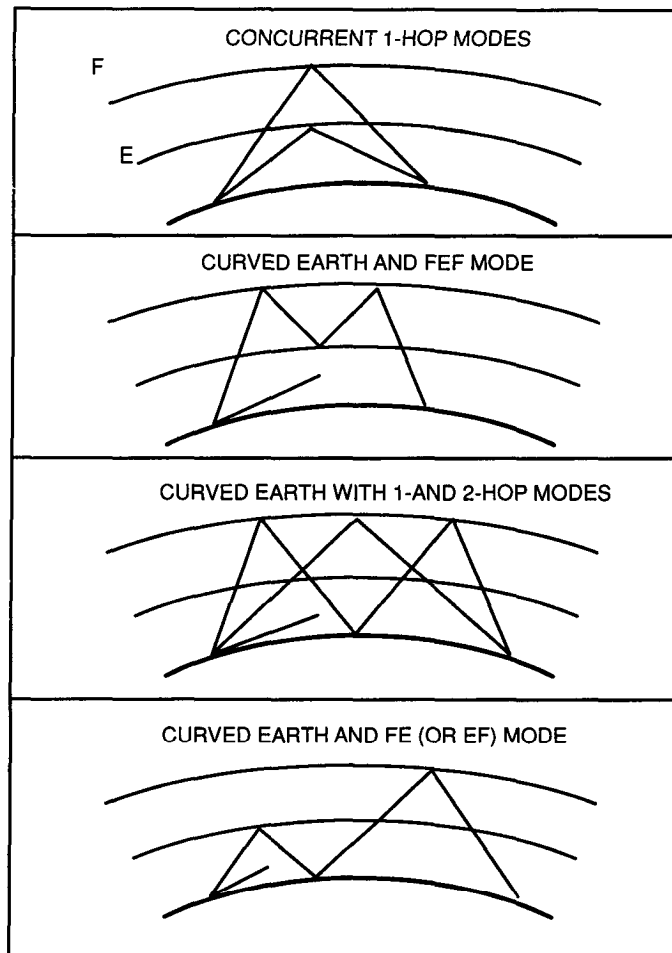


Figure 8-37. Alternative discrete mode propagation paths.

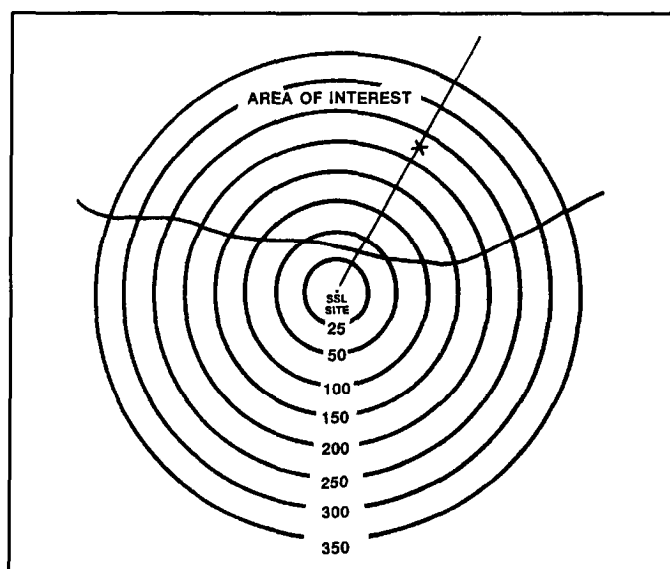


Figure 8-38. Fix point along the line of bearing.

Wild Bearings

In fixes using four or more station's bearings, it may become obvious to the plotter or analyst that a plot contains a *wild bearing*. This is a bearing that shows considerable deviation from the fix created by the other DF stations' bearings. For example, observe the plot illustrated in Figure 8-39. Obviously, site 2 is a wild bearing. In such a situation, the plotter or analyst can disregard the bearing completely when analyzing the fix area.

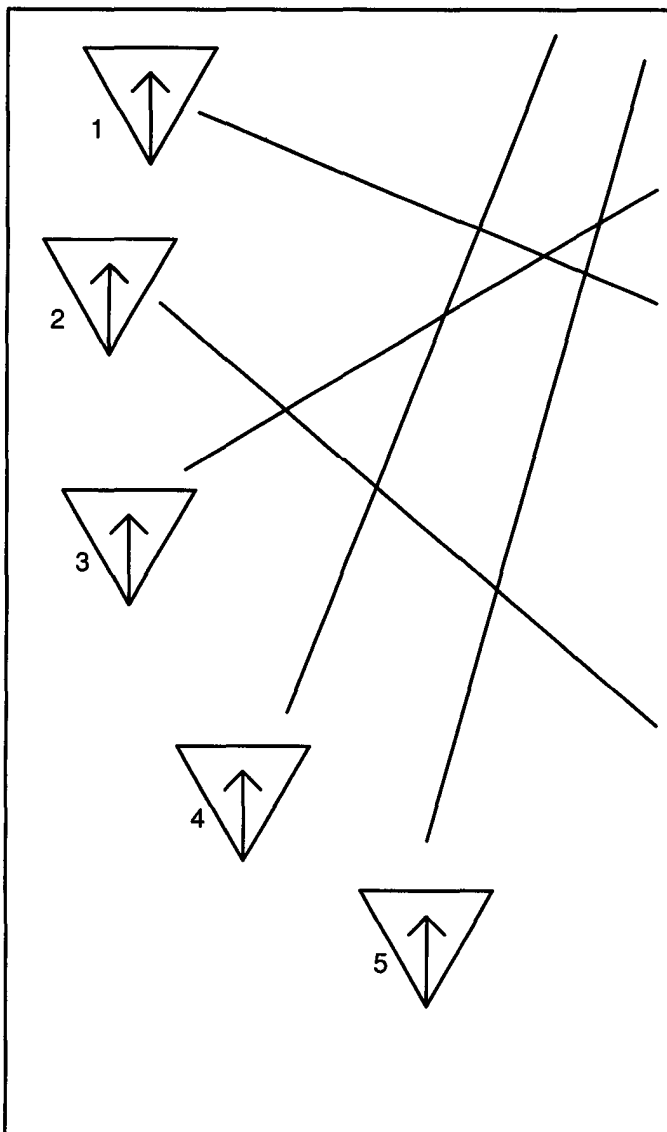


Figure 8-39. Wild bearing.

Radius Determination

A *fix radius* is a circular area wherein there is a high probability of a target's location. Radius determination can be used with all plotting or analysis methods and techniques with the exception of SSL plotting or analysis. In the past, the radius was determined by measuring from the fix point to the shortest line which joins the angles of intersection. Using this method, there is only a 25 percent probability that the target will be within the radius. Use of the *longest line* will increase the probability factor from 80 to 90 percent. However, such an enlarged radius diminishes the usefulness of the DF information to the consumer. Therefore, the radius shall include a majority but not all of the bearing intersections, thus providing a 45 to 60 percent probability. The procedure for applying a fix radius to your fix point on a tactical map is as follows:

- Place the length of a piece of paper (or measure with a ruler) along the fix point and the second farthest angle of the geometric figure (Figure 8-40, page 8-20).
- Mark on the paper (or measure) the locations of the fix point and the intersection at the second farthest angle (from the fix point).
- Place the paper (or ruler) on the scale at the bottom of the map to get the actual distance.

This distance, in a circular pattern centered at the fix point, is the fix radius or area of probability.

NOTE: The initial placement of the fix point (.) is the approximate center of geometric error area. The fix point is then moved considerably toward the 90 degree angle which is formed by sites 1 and 2. At their respective distances, sites 1 and 2 have the lowest SD of the three participating sites. The radius is computed to intersection B because a radius applied to B will encompass both intersections A and B, constituting a majority (two of three).

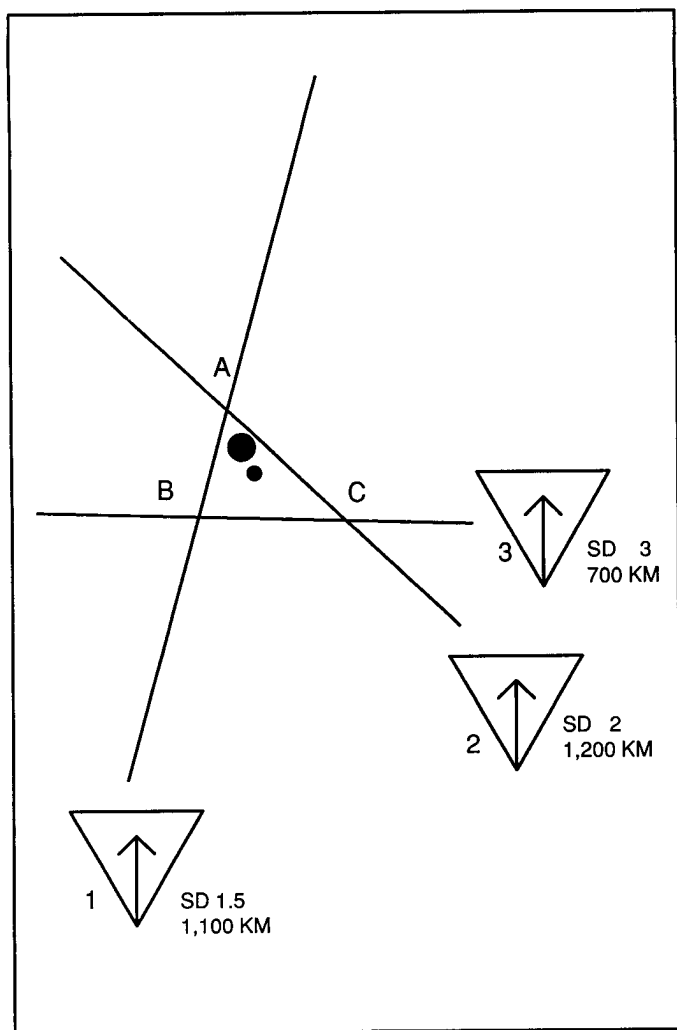


Figure 8-40. Initial placement of a fix.

The procedure for radius determination on gnomonic maps (strategic) is similar to that of UTM maps (tactical). The difference lies in the procedure for measuring the distance of the radius. Instead of equating the length on a tactical map to a given scale, the strategic analyst reads distance directly from the gnomonic map (Figure 8-41). Each square formed from the latitude and longitude lines on the map equates to a distance of 60 Nm. Inside of each square are three rows each of horizontally and vertically oriented dots that are parallel to the latitude and longitude lines. Each dot equates to 15 Nm distance. To determine radius, the length is measured in the same way as on a tactical map. The distance is calculated by placing the paper or ruler in the same area as the fix point, and using the dots inside the

square to estimate distance. The paper should be oriented along lines of longitude or latitude, depending on the alignment of the radius measurement. For example, if the line from the fix point to the angle of intersection is oriented along an east-west direction, then the distance measurement will be made using the east-west longitudinal dots. If the analyst wishes to convert the radius to statute miles (Sm), the analyst simply multiplies the determined radius in Nm by 1.15.

Some tactical DF systems have computers which will produce a fix point (in UTM or geographic coordinates) and an elliptical error probability (EEP) or circular error probability (CEP) radius. CEP is a radius that encompasses one-half of the errors in a two-dimensional error distribution system. It does not analyze geometric configurations. EEP determines the length (major axis) and width (minor axis) of the geometric figure, producing an elliptical radius that is based on error calculations similar to those in CEP evaluations.

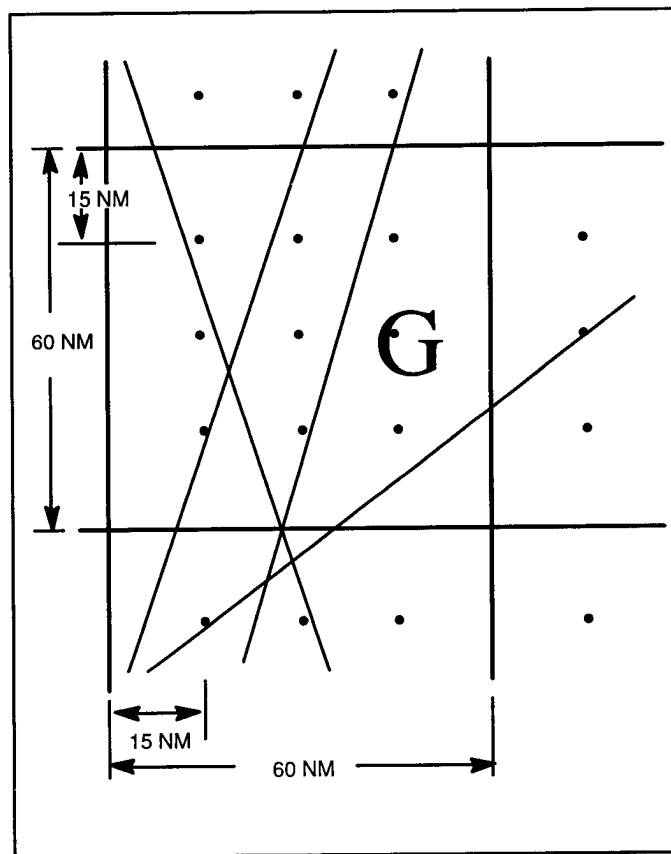


Figure 8-41. Reading distance from the gnomonic map.

Composite Plotting and Analysis

Composite plotting is the process of compiling and averaging bearings obtained over a period of time from a target entity. Composite plotting techniques enable the DF analyst to obtain a more accurate and refined fix area for an emitter under surveillance. The accuracy of the composite plot is also affected by the number of bearings available for averaging. The greater the number of bearings used in the computation, the more accurate the results. The term *composite plotting* is a misnomer. It is used to describe an arithmetic process. After the process is completed, the mean (averaged) bearings are plotted

To make a composite plot, past results are evaluated and a mean bearing is computed for each DF site.

The DF analyst first determines the mean bearing grouping (MBG) of the bearing from each DF site. The MBG is the close numeric grouping of bearings.

Bearings are examined to determine if any bearing deviates plus or minus 10 degrees from all other bearings

in the group. Figure 8-42 and 8-43 illustrate this process. In this example, 42 degrees is removed from the calculation because it has a 12 degree deviation from the outermost bearing limit.

SITE B	
17°	
17°	
18°	
42°	
17°	
17°	
18°	
19°	
18°	
20°	
18°	
20°	
22°	
27°	
25°	
30°	
28°	
20°	

Figure 8-42. Compiled list of bearings.

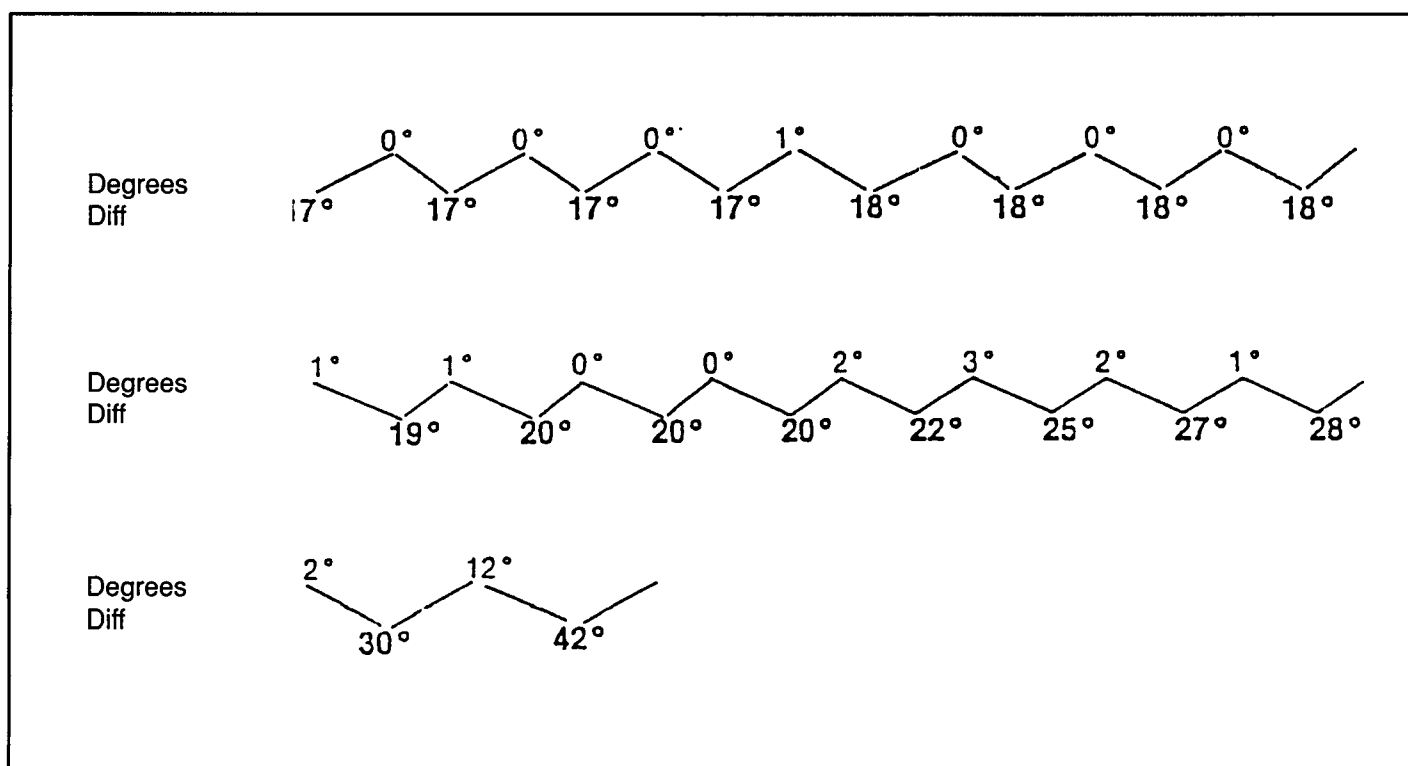


Figure 8-43. MBG determination.

After determining the MBG, the analyst eliminates from the list, any bearings which are more than 10 degrees beyond the upper and lower limits of the MBG. As illustrated in Figure 8-44, the limits of the adjusted MBG are 7 and 40 degrees. Any bearings less than 7 or more than 40 degrees are discarded.

$\begin{array}{r} 17^{\circ} \text{ (lower limit of MBG)} \\ -10^{\circ} \\ \hline 7^{\circ} \end{array}$	$\begin{array}{r} 30^{\circ} \text{ (upper limit of MBG)} \\ +10^{\circ} \\ \hline 40^{\circ} \end{array}$
---	--

Figure 8-44. Adjusted MBG.

The analyst now computes an initial mean bearing, as illustrated in Figure 8-45 and Figure 8-46. Studying these lists of bearings, the analyst will eliminate any bearings that are plus or minus 8 degrees from the initial mean bearing resulting in an intermediate mean bearing.

SITE B BEARINGS	
	17°
	17°
	18°
	17°
	17°
	18°
	19°
	18°
+	20°
	18°
	20°
	22°
	27°
	25°
	30°
	28°
	20°
	SUM 351°

Figure 8-45. Initial mean bearing.

351 (sum of bearings) ÷ 17 (number of bearings) = ?	
$\begin{array}{r} 20.6 \\ 17 \overline{) 351.0} \\ \underline{34} \\ 11 \\ \underline{0} \\ 110 \\ \underline{102} \\ 8 \end{array}$	$20.6 = 21^{\circ}$ (rounded to nearest whole degree)

Figure 8-46. Intermediate mean bearing.

The analyst then recomputes a final mean bearing from the remaining bearings. The analyst repeats the process of eliminating any bearings plus or minus 8 degrees from the intermediate mean bearing. A check of the computations in Figure 8-47 and a check of the list of bearings in Figure 8-48 shows that no bearing needs to be eliminated in the example. Therefore, the mean bearing of 20 degrees (Figure 8-49) is plotted as the final mean bearing for the example DF site. This process must be completed for each DF site.

$\begin{array}{r} 21^{\circ} \text{ (mean from previous step)} \\ -8^{\circ} \\ \hline 13^{\circ} \end{array}$	$\begin{array}{r} 21^{\circ} \text{ (mean from previous step)} \\ +8^{\circ} \\ \hline 29^{\circ} \end{array}$
--	--

Figure 8-47. Determining bearing limits.

SITE B BEARINGS	
	17°
	17°
	18°
	17°
	17°
	18°
	19°
	18°
+	20°
	18°
	20°
	22°
	27°
	25°
	28°
	20°
	SUM 321°

Figure 8-48. Bearing list.

321 (sum of bearings) ÷ 16 (number of bearings) = ?	
$\begin{array}{r} 20.0 \\ 16 \overline{) 321.0} \\ \underline{32} \\ 01 \\ \underline{0} \\ 10 \\ \underline{0} \\ 10 \end{array}$	$20.0 = 20^{\circ}$

Figure 8-49. Final mean bearing.

Computer Plotting and Analysis

Computerized plotting and analysis of direction finding results is also possible in most strategic DF networks and some tactical systems. The tactical systems with computerized plotting and analysis provide the battalion operations center with near real-time direction finding fix information on targets of interest. In either case, the outstation's bearings are entered into a computer which is programmed to compute the fix location in either geographic or grid coordinates. A fix or no fix of the target transmitter's antenna is quickly determined. The basis for all computer plotting is called the *least square method*.

FFIX is a computer program written in formula translation (FORTRAN) that will compute a fix point and an interval estimate or confidence ellipse when given DF bearings. FFIX is used in all Army strategic DF site computer fix programs. Any other computer programs must be specifically approved by NSA. The input for FFIX consists of the site locations (latitude and longitude) and the SD associated with the respective site. The objective of the algorithm is to identify the largest consistent or cohesive subset of bearings by rejecting wild bearings and then computing the fix point and confidence region for that subset of bearings. (For analytical purposes, the confidence region can be considered the same as a circular radius.) The fix point is computed by the method of maximum likelihood, which is equivalent in this case to the method of least squares.

Currently, the FFIX site look-up table has been programmed for up to 32 or 55 DF sites. The exact number of site inputs depends upon the individual station's requirements. The look-up table stores all pertinent parameters for each site. For the composite fix version, the bearing arrays have been increased to handle 1,000 bearings.

Included in the input data provided to the program are the SD statistics for each site. This SD should represent the SD for targets at a range of 1,000 Nm. This is important because FFIX weighs each site SD as a function of the distance between the site and the fix point. Therefore, if mutually acceptable results are

desired among all users of the algorithm, then all users must use the same SD statistics. (It is the National Security Agency's intention to be in a position to provide the DF sites with the appropriate SD statistics.) If desired, such statistics can be obtained individually by developing site SD/distance curves (see Chapter 9).

Two methods of computer plotting are—

- Exhaustive method.
- Sequential method.

Exhaustive Method

The objective of the algorithm is to identify the largest consistent or cohesive subset of bearings and then compute the fix point and ellipse for that subset of data. In doing so, the program employs two methods for identifying the wild bearings to be rejected. The first approach, known as the *exhaustive* method, is used when 10 or less bearings are submitted. This approach begins by examining the consistency of all the submitted bearings. If all the bearings lack sufficient consistency to qualify as a fix, then the program examines all subsets of bearings until an acceptable fix is identified or until a lower limit on the bearing information is reached. In this approach, all combinations of bearings are exhaustively examined to identify the largest subset of consistent bearing information.

Sequential Method

The second approach, known as the *sequential* method, is used when a bearing set contains more than 10 bearings. It begins by examining the consistency of all the bearings. If all of the bearing responses lack sufficient consistency to qualify as a fix, then the bearing that is more inconsistent with the set of bearings is rejected. The remaining set of bearings is then reexamined in the same way to determine if they are sufficiently cohesive to qualify as a fix. In this manner, the most inconsistent and generally the wildest bearings are rejected sequentially. It is impossible to enter the exhaustive mode of bearing rejection once the program is in the sequential mode.

The same method of determining the confidence region is used in the exhaustive method and the sequential method. The determination of the confidence ellipse (similar to a circular radius) is based on the variance of

the bearings to the fix point. (Bearing errors and target errors are treated as differentials.) Therefore, the computation of the confidence ellipse is independent of the reported bearings. Further information about the

FFIX (and the FORTRAN program) may be obtained by writing to:

National Security Agency/Central Security Service
(NSACSS) ATTN: P38, DDI RNO
Fort George G. Meade, Maryland

ROTATING ROSE PLOTTING

Tactical direction finding equipment will be very mobile in a fluid combat situation. This necessitates an easily adaptable plotting method such as the rotating rose method. The rotating rose method of plotting enables the DF plotter to plot bearings which have been adjusted to true north using a grid map. The intersections of these bearings form a geometric figure on the map where the target emitter's antenna is most probably located. The rotating rose method is used exclusively for tactical plotting on a UTM 1:50,000 map sheet. It is easy to construct and takes a minimum of time and materials. The following materials (Figure 8-50) are needed to construct a rotating rose:

- A 1:50,000 universal transverse mercator map projection.
- Grease pencil.
- Thumbtack.
- Pencil.
- Straightedge.
- Sheet of paper.
- Scotch tape.
- Acetate sheet large enough to cover the map projection.
- True rose (Figure 8-51).

To prepare a UTM 1:50,000 map sheet for rotating rose plotting, first place the map on a smooth, flat surface. Tape it down on all four corners. Ensure the map is stretched as flat as possible, otherwise it could affect the accuracy of the plotting. Once the map is in place, note the latitude-longitude tick marks on each side of the map. They are spaced at 5 degree intervals. There are a total of eight tick marks (Figure 8-52).

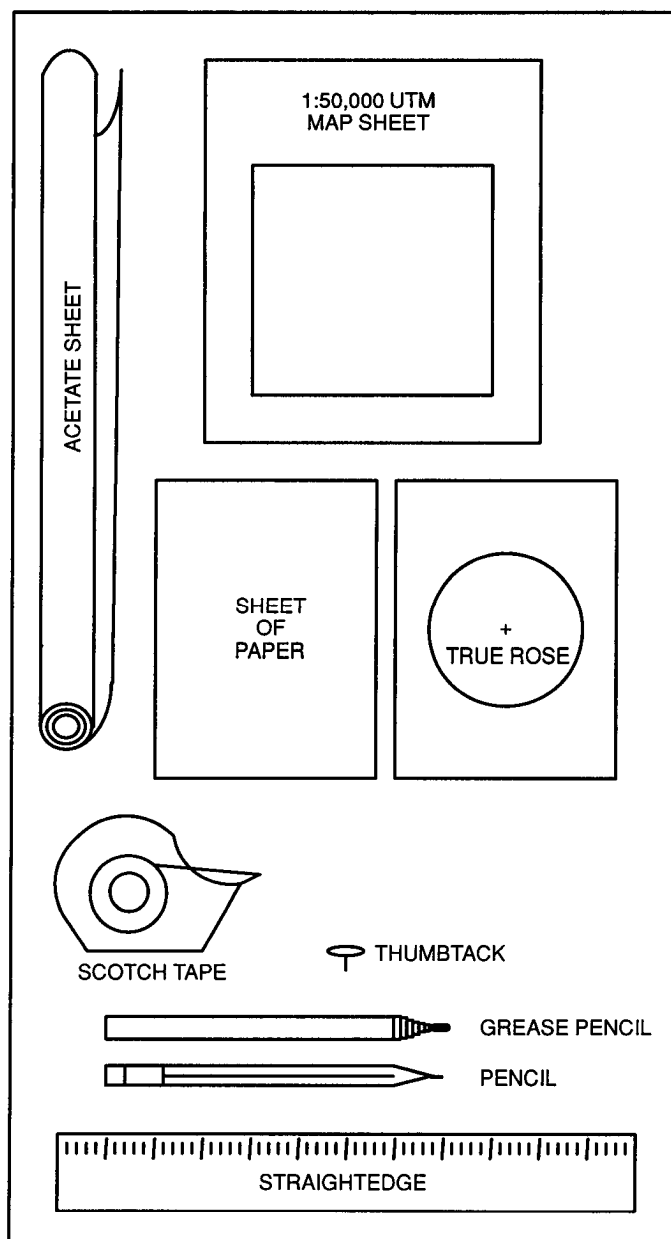


Figure 8-50. Materials needed to construct a rotating rose.

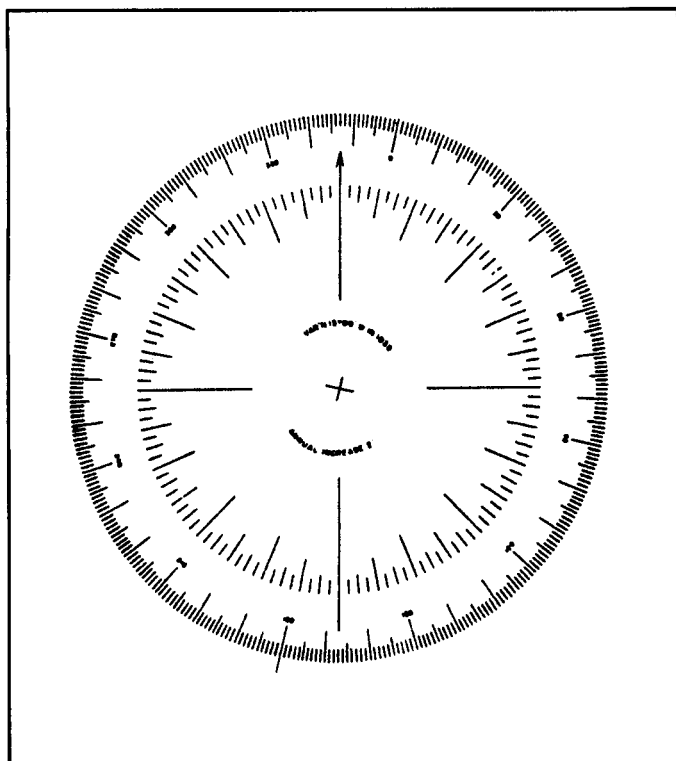


Figure 8-51. True rose.

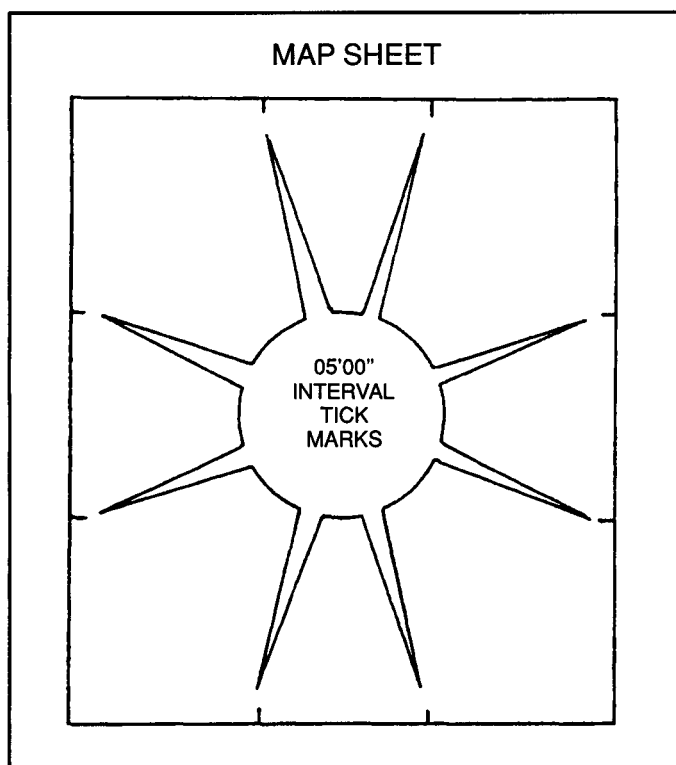


Figure 8-52. Tick marks.

Also note that on a 1:50,000 map sheet there are four cross tick marks—one in each quadrant (Figure 8-53).

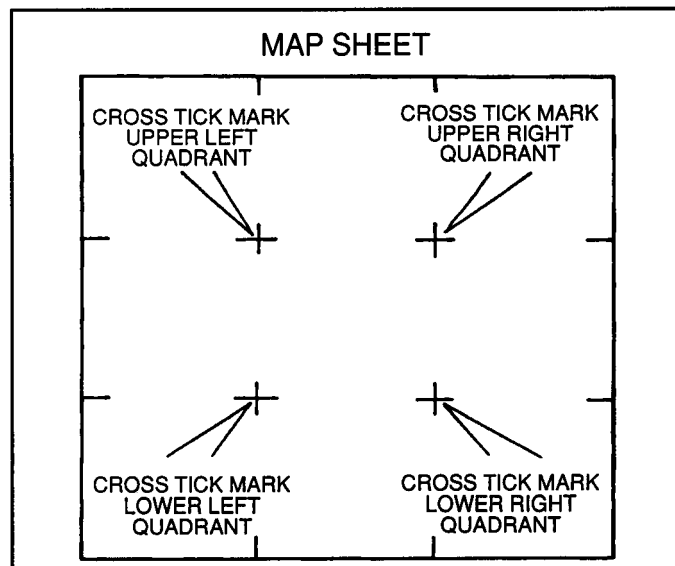


Figure 8-53. Locating the cross tick marks.

These lines indicate where the lines of latitude and longitude cross. Since all lines of longitude are true north-south lines, the latitude-longitude cross tick marks are used to establish a true north-south line on the map. The plotter must construct a true north-south line directly on the map sheet. To do this, use the following steps:

STEP 1. Locate the bottom left-hand tick mark on the map (Figure 8-54).

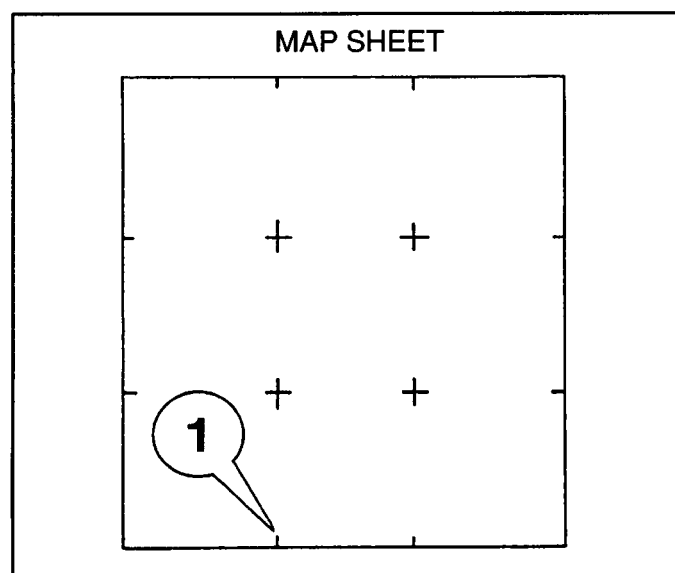


Figure 8-54. Locating tick marks.

STEP 2. Locate the exact center of the cross tick mark in the lower right quadrant of your map. Using a straightedge, draw a connecting diagonal line (Figure 8-55).

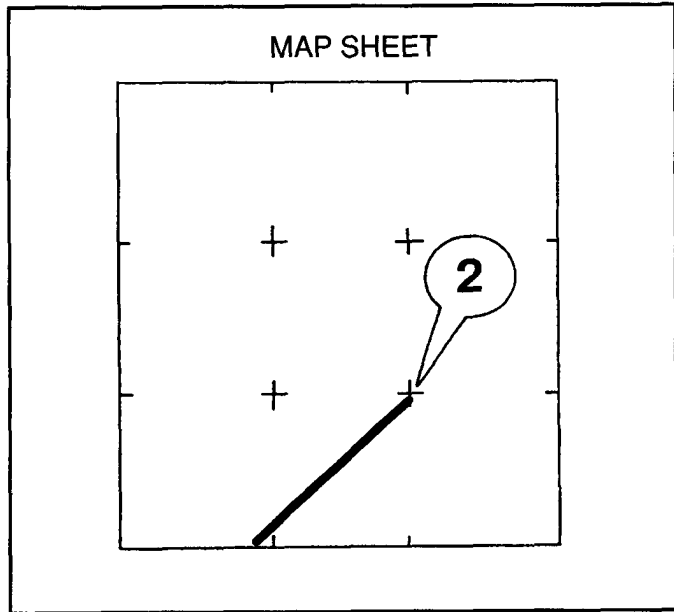


Figure 8-55. Connecting diagonal line.

STEP 3. Locate the exact center of the cross tick mark in the upper left quadrant. Draw a diagonal line connecting it with the center of the cross tick mark in the lower right quadrant (Figure 8-56).

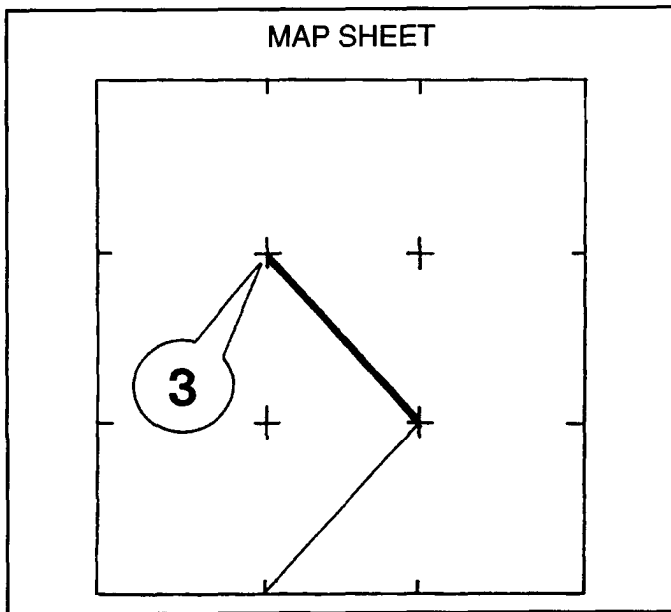


Figure 8-56. Connecting tick marks.

STEP 4. Locate the tick mark in the top right quadrant. Using the straightedge, connect it with the center of the cross tick mark in the upper left quadrant (Figure 8-57). The result is a zigzag pattern which extends the full length of the map.

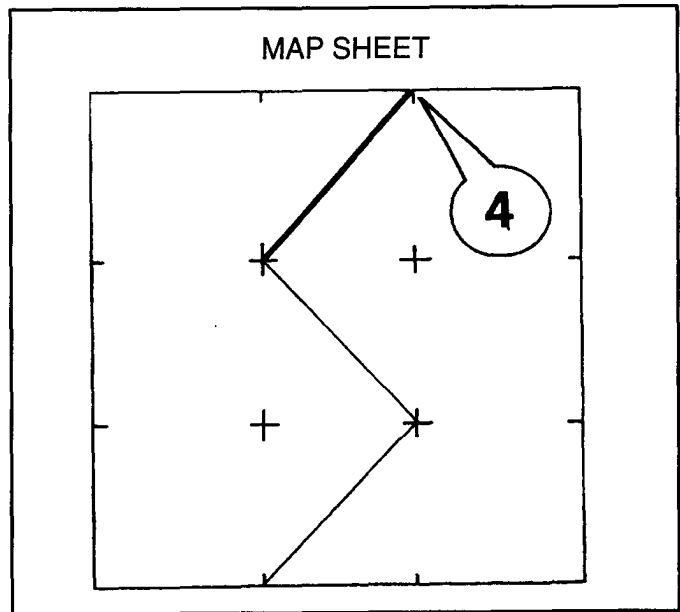


Figure 8-57. Zigzag pattern.

STEP 5. Now repeat the process in reverse. When completed, your map sheet should look the same as Figure 8-58.

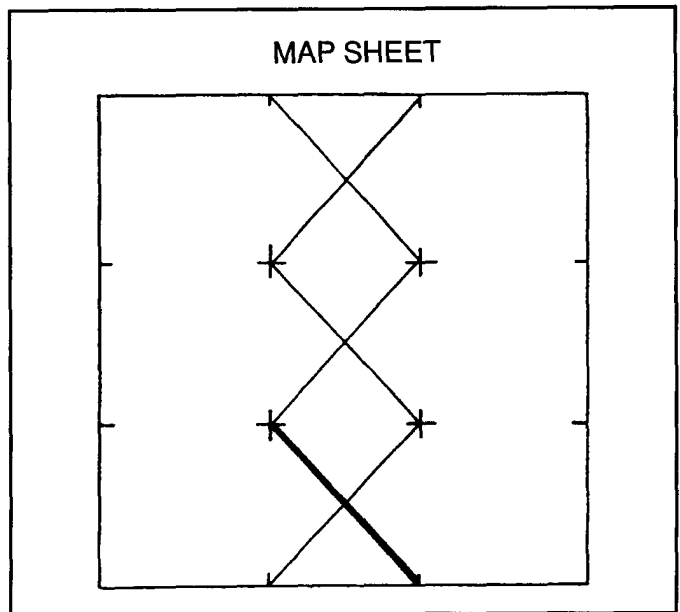


Figure 8-58. Double zigzag pattern.

STEP 6. Align the center points of the Xs with a straightedge and draw a line the complete length of the map (Figure 8-59). This is your true north-south line. Ensure this line is well defined on the map sheet. It will be used for reference when plotting.

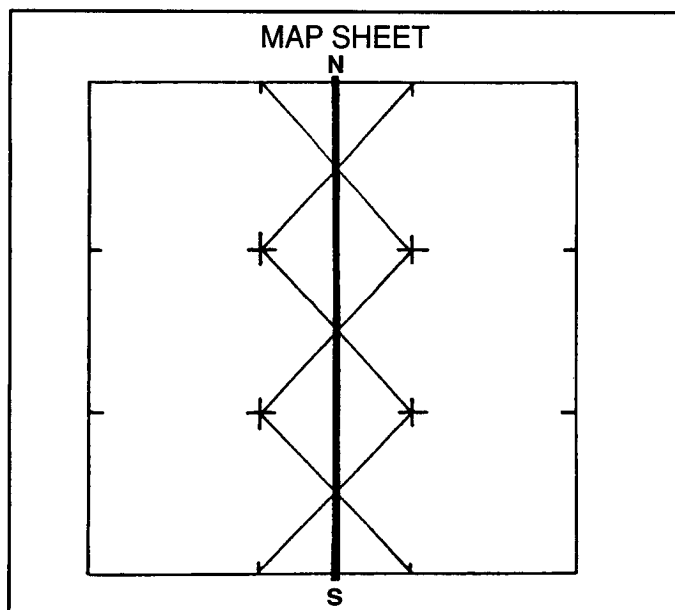


Figure 8-59. True north-south line.

The next step in rotating rose plotting is to locate the DF sites on the map (Figure 8-60). Ensure each site is pinpointed according to its grid coordinates. Use the following steps:

STEP 1. Identify each site with a letter designation such as site A or site B (Figure 8-60). Use different colored pencils for ease in each site identification.

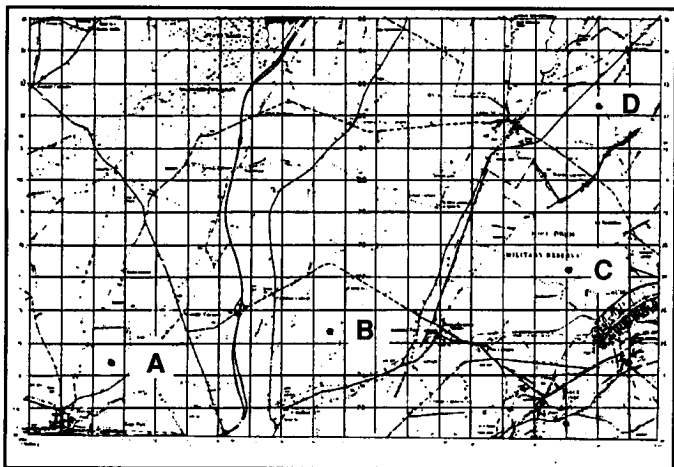


Figure 8-60. Placing DF sites on the map.

STEP 2. Once the sites have been clearly located and marked on your map sheet, lay a piece of acetate over the map (Figure 8-61).

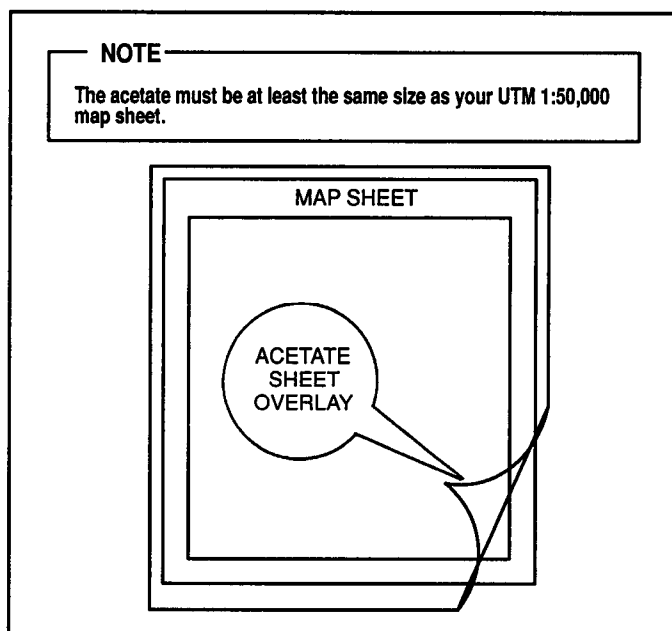


Figure 8-61. Placing acetate over the map.

STEP 3. Place the true rose in the center of your map and tape securely to the acetate (Figure 8-62).

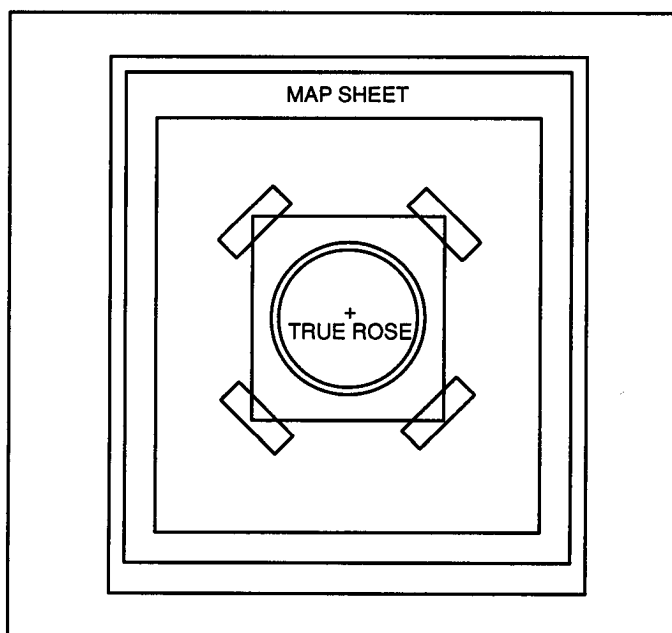


Figure 8-62. Placing the true rose on the map.

STEP 4. Align the 0/360 degree and 180 degree marks of the true rose with the center true north-south line previously drawn on the map (Figure 8-63).

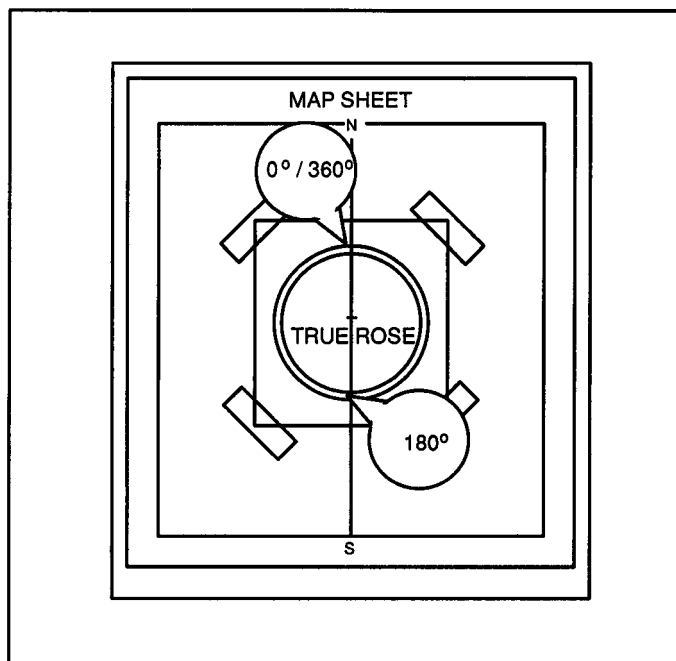


Figure 8-63. Aligning the true rose.

STEP 5. Push a thumbtack through the exact center of the true rose (Figure 8-64). The true rose should now be securely pinned to the map—but free to rotate.

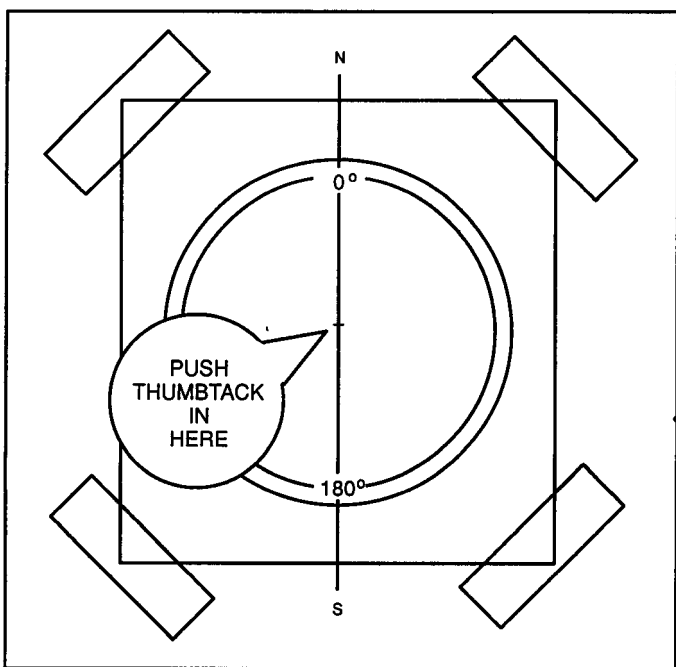


Figure 8-64. Thumbtack placement.

STEP 6. Transfer the locations onto the acetate. However, first ensure the 0/360 degree and 180 degree marks of the true rose are aligned with the true north-south line. Then mark the position of each previously located direction finding site onto the acetate overlay with your grease pencil. To differentiate between the sites marked on your map and those marked on the acetate, circle the letter designations on the acetate (Figure 8-65). The map is now ready to begin plotting.

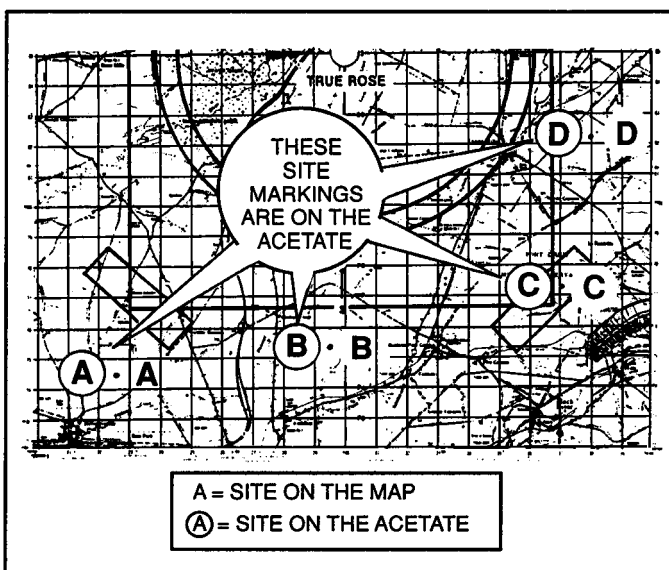


Figure 8-65. Placing DF sites onto the acetate.

To demonstrate how the rotating rose plotting is performed, the following illustrations are provided. Each plotting step is illustrated and is applicable to particular tactical situations. The method remains the same. The difference will be in the—

- Map used.
- Total number of DF sites.
- Site locations.
- Reported bearings.

Assuming that the sites are now clearly marked on the map and acetate as illustrated in Figure 8-65, we will plot the following bearings:

- SITE A - 020°.
- SITE B - 340°.
- SITE C - 290°.
- SITE D - 265°.

Initially, we will start with bearing A to illustrate a step-by-step plotting procedure. The reported bearing is 020 degrees. The following steps are used.

STEP 1. Rotate the compass rose until 020 degrees is aligned with the true north-south line on the map (Figure 8-66).

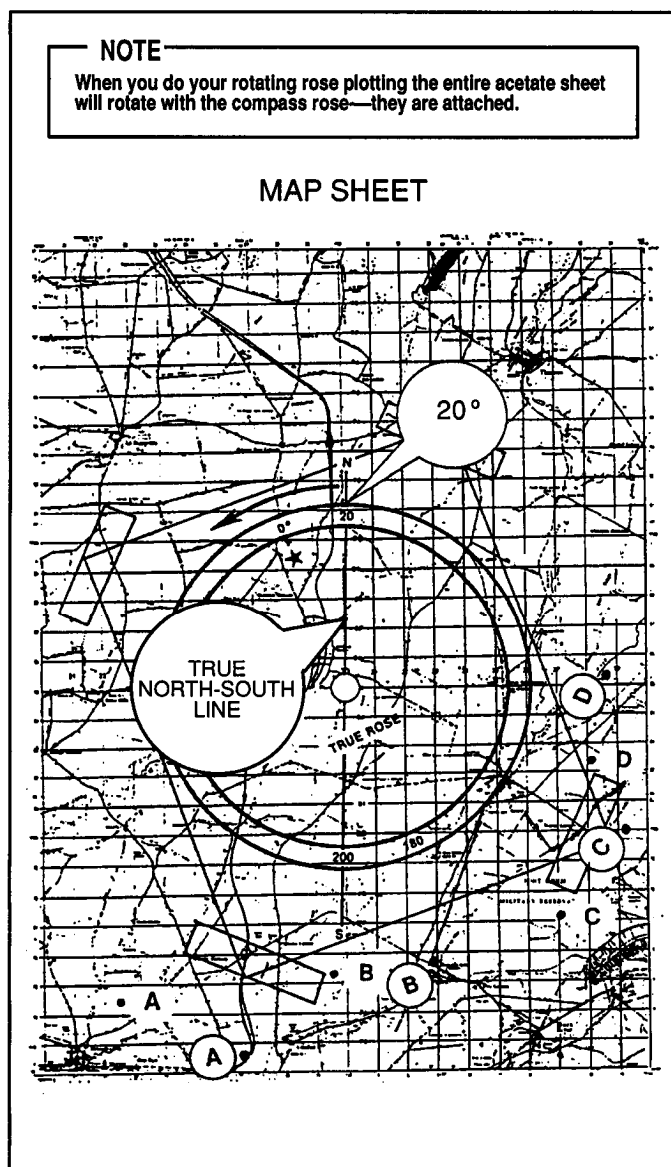


Figure 8-66. Plotting site A's bearing.

STEP 2. Take a sheet of paper and align the long edge with the center true north-south line and the bottom edge with site A on the acetate (Figure 8-67). Make a small tick mark on the bottom edge of the sheet of paper at the point where site A is aligned.

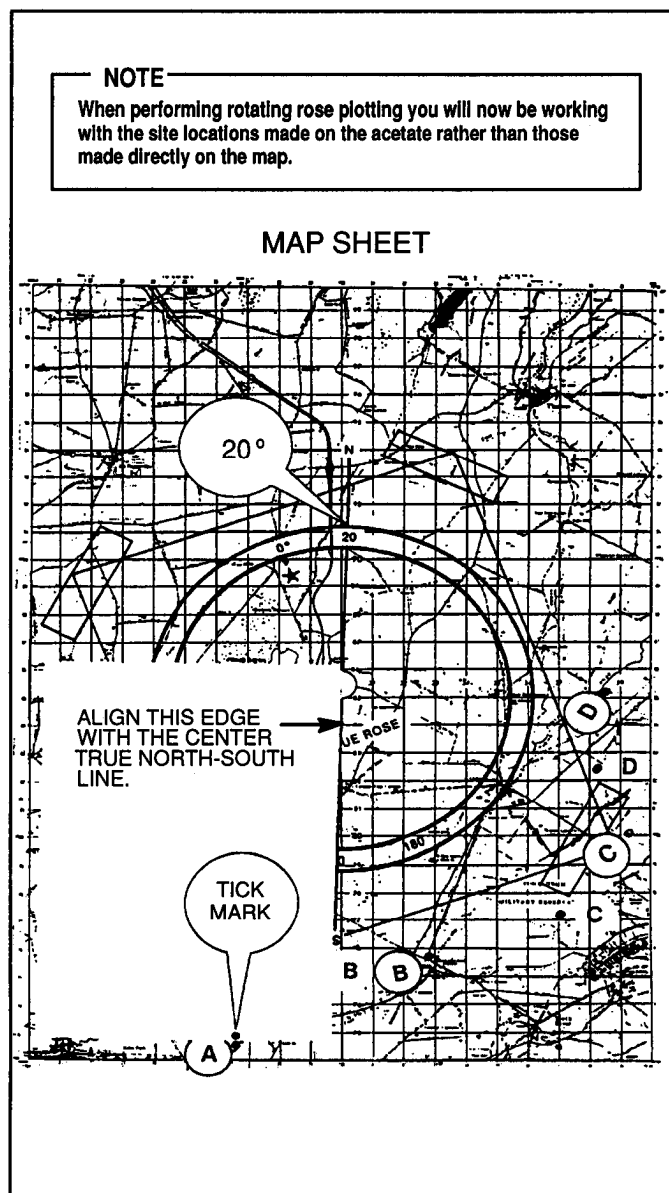


Figure 8-67. Aligning paper with center true north-south line and site A.

STEP 3. Slide the sheet of paper up along the true north-south line until the top edge is aligned with the tip of your map sheet. Ensure the long edge and the center true north-south line are as previously aligned. Place a tick mark on the acetate directly below the tick mark on the bottom edge of the paper (Figure 8-68). This was the tick mark that identified the location of site A.

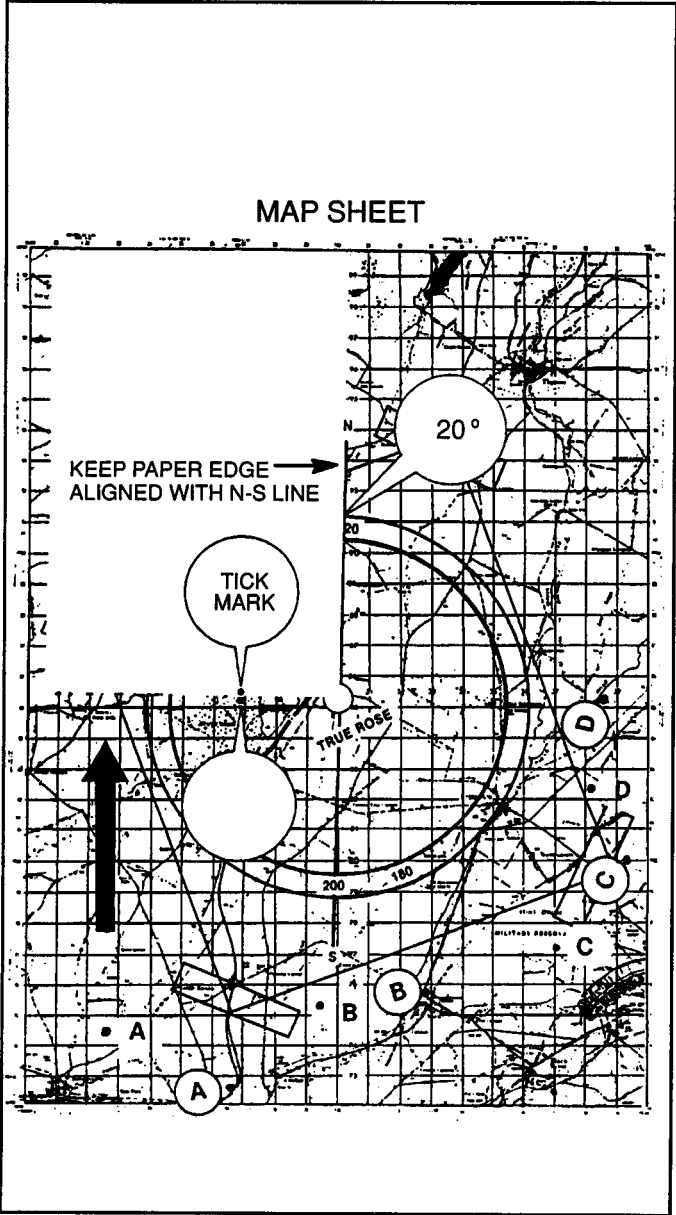


Figure 8-68. Tick mark placement.

STEP 4. Using a straightedge, align the tick mark just made with site A on the acetate. Using a grease pencil, connect these points and extend the line as far as possible (Figure 8-69).

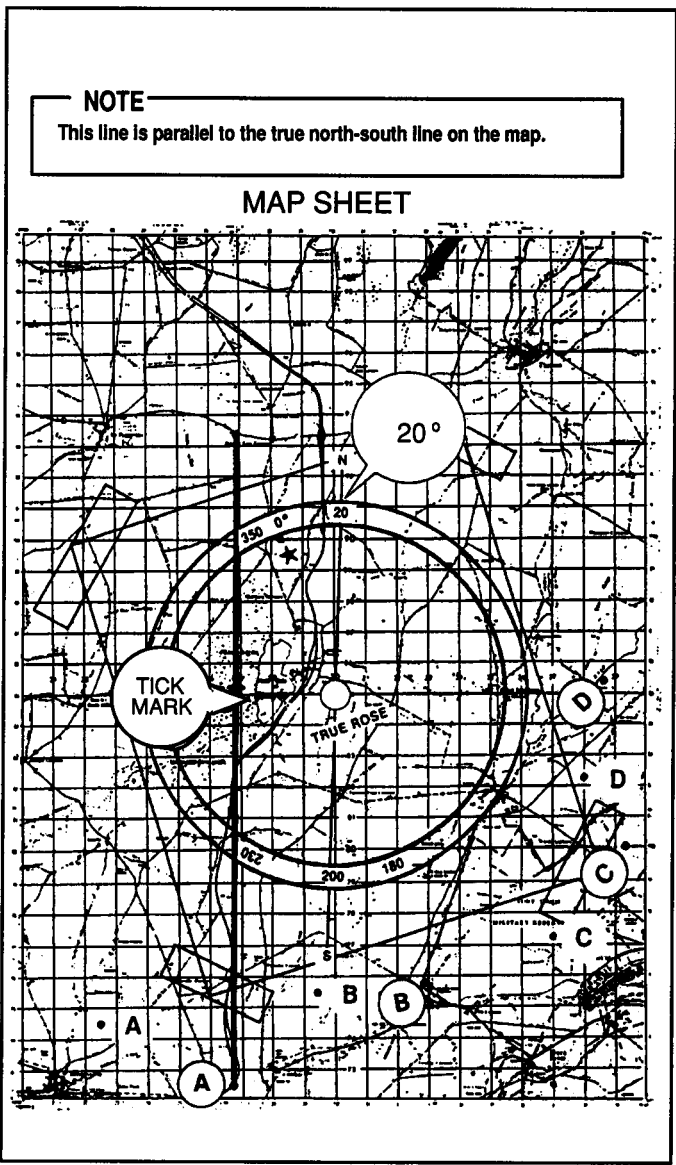


Figure 8-69. Line drawn between site A and tick mark.

STEP 5. Plot the 340 degree bearing for site B. Rotate the true rose to align the 340 degrees with the center true north-south line (Figure 8-70).

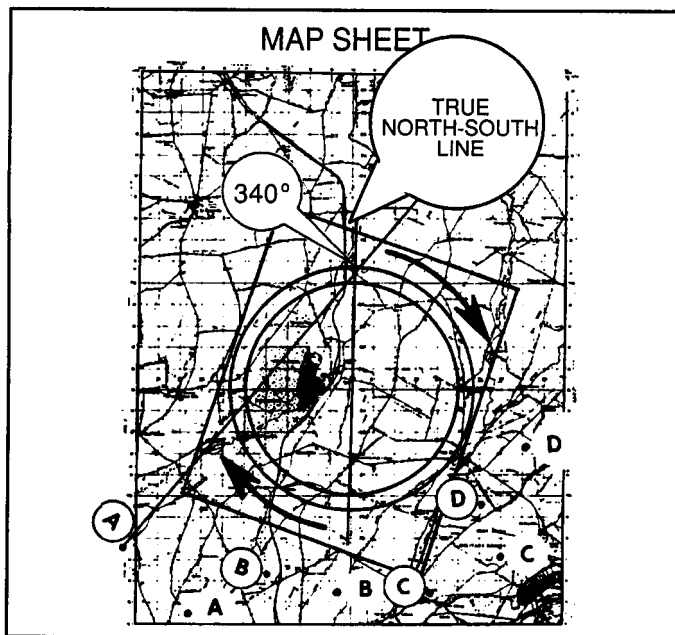


Figure 8-70. Plotting site B's bearing.

STEP 6. Align the long edge of the paper with the true north-south line and the bottom edge of the paper with site B on the acetate. As illustrated in Figure 8-71, make a tick mark on the paper at the point where site B is aligned.

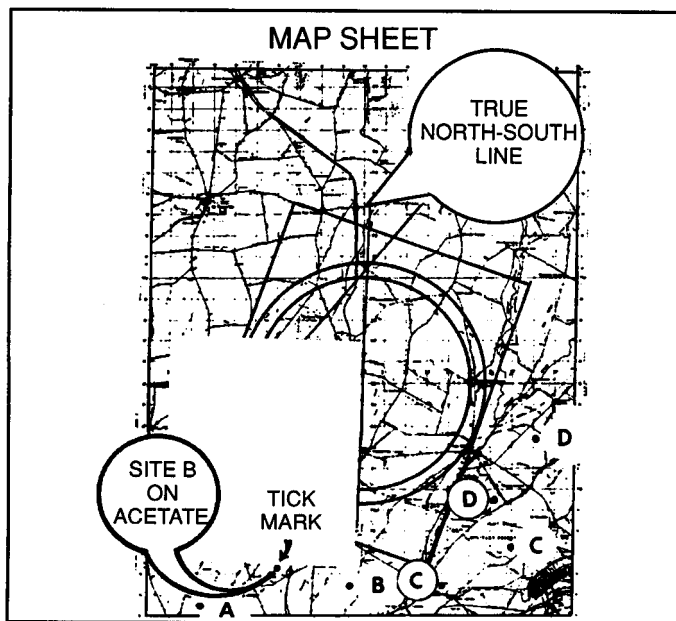


Figure 8-71. Placing tick mark on paper.

STEP 7. Slide the sheet of paper up until the top edge is at the top of the map sheet. Ensure the long edge is aligned with the true north-south line. Place a tick mark precisely below the tick mark on the bottom edge of the paper (Figure 8-72).

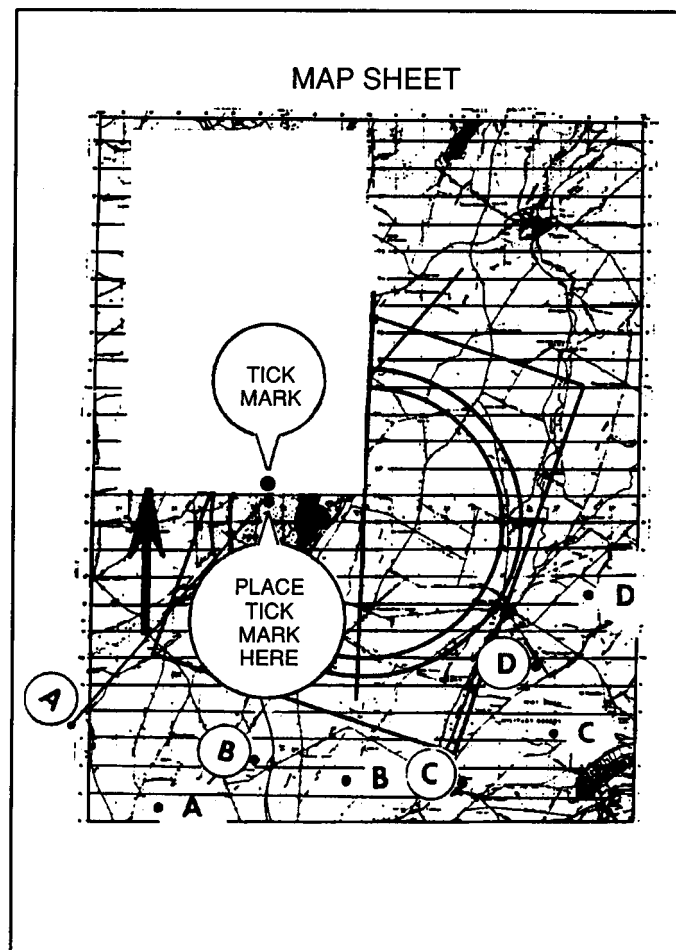


Figure 8-72. Tick mark placement.

STEP 8. Taking a straightedge, align the tick mark just made with site B on the acetate. Draw a line through the two points as far as possible (Figure 8-73).

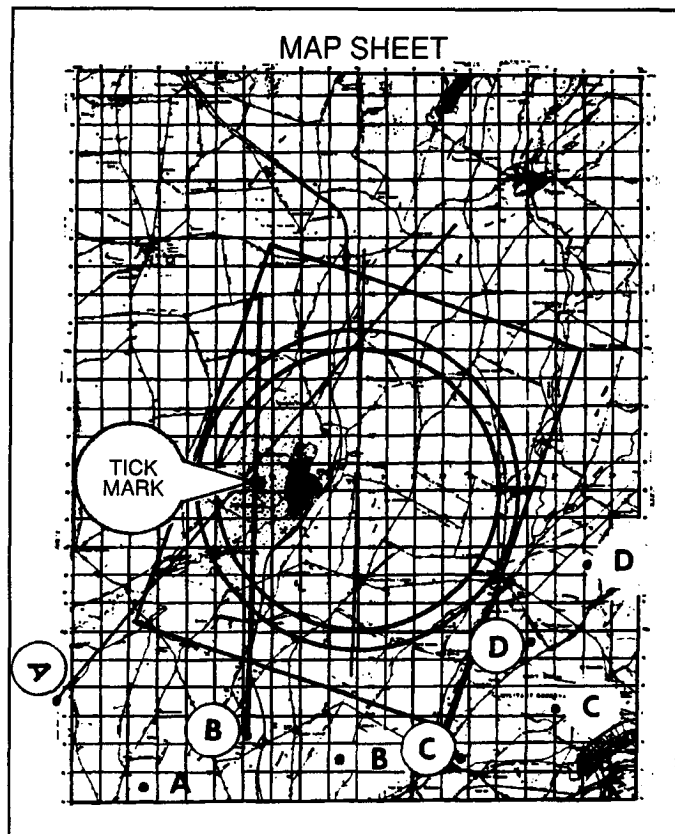


Figure 8-73. Line drawn between site B and tick mark.

Plotting the bearings for sites C and D are completed in exactly the same manner. Once the site C bearing of 290 degrees and site D bearing of 265 degrees are plotted, the acetate will indicate a fix area as illustrated in Figure 8-74. The most probable fix location can then be determined and reported in a 8-digit coordinate. Since the bearings were plotted using a grease pencil, they can now be erased from the acetate and the map is ready to plot the next bearing returns.

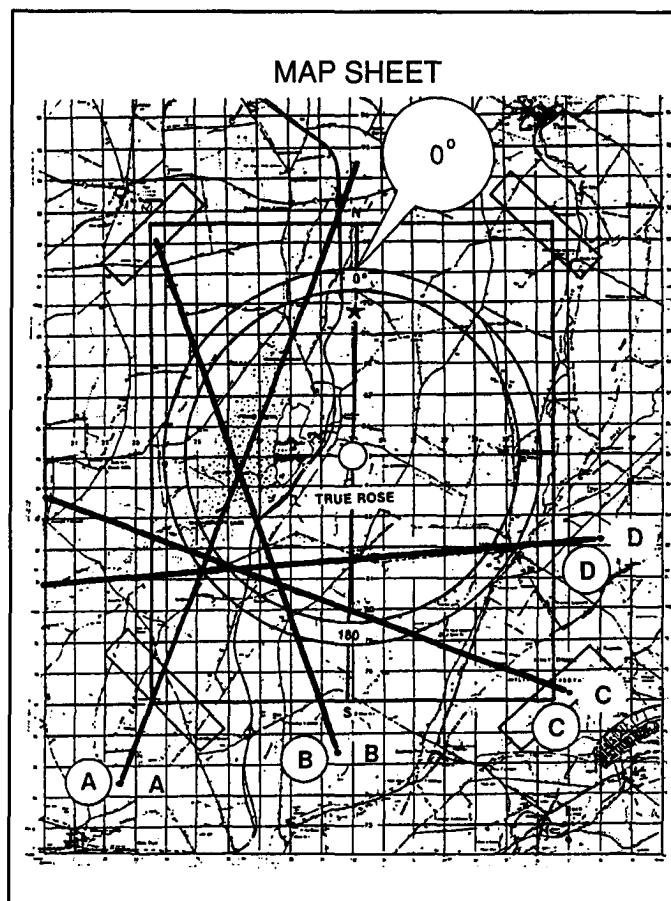


Figure 8-74. The completed plot.

CHAPTER 9

COMPUTATIONS

In Chapter 8, we discussed how maps used in tactical and strategic direction finding operations are developed. Normally, these maps are projected on a plane or a cylinder. Regardless of the projection technique used in developing a map, there will be some distortion. Most strategic DF plotting facilities use mathematical computations to correct this distortion. Tactical plotting operations normally do not compute for map distortion. This is because of the distance from the DF site to the target area (5 to 30 kilometers) and the limited personnel resources and time. It is also not feasible in a tactical environment due to the frequent movement of the DF sites.

We have also discussed how radio waves travel great circle paths. Therefore, using mathematical computations, it is possible to compute the true bearing and distance from a DF site to a known transmitter. These computations are then used to determine the performance of a direction finding site. Normally called statistical analysis, these mathematical computations can reveal DF equipment or operator error. As a management tool, computations can evaluate the DF site as well as the net performance.

MAP DISTORTION CORRECTION TECHNIQUES

The gnomonic projection is the most commonly used map projection for strategic DF plotting (Figure 9-1). It is derived by projecting the surface of the globe, from a center point, upon a planar surface. Its primary

characteristic is that all great circles appear as straight lines. This map is particularly useful when plotting across great expanses of ocean. Distortion on the gnomonic projection is minimal at the point of tangency.



Figure 9-1. Gnomonic projection.

However, distortion increases as the distance from the point of tangency increases. For example, the boundaries near the edge of the map projection are badly distorted and are practically useless for determining true shapes and distances. This distortion does not affect plotting activities if the DF equipment is located within a 4-degree radius from the point of map tangency. Bearings can be plotted to any point on the chart without any appreciable error. However, if the DF station is located outside the 4-degree radius, angular correction must be applied before its bearings can be accurately plotted. The computation methods used to correct this distortion are—

- Border coordinates.
- Corrected compass rose.

Border Coordinates

Border coordinates are used to correct angular distortion on a gnomonic chart. They also provide what is perhaps the most accurate method of manually plotting DF bearings. Border coordinates divide the perimeter of the gnomonic chart into 1,000 equal spaces. The spaces are denoted by tick marks. Every tenth mark is numbered, starting with 00 at the upper left corner and continuing clockwise to 100 (Figure 9-2).

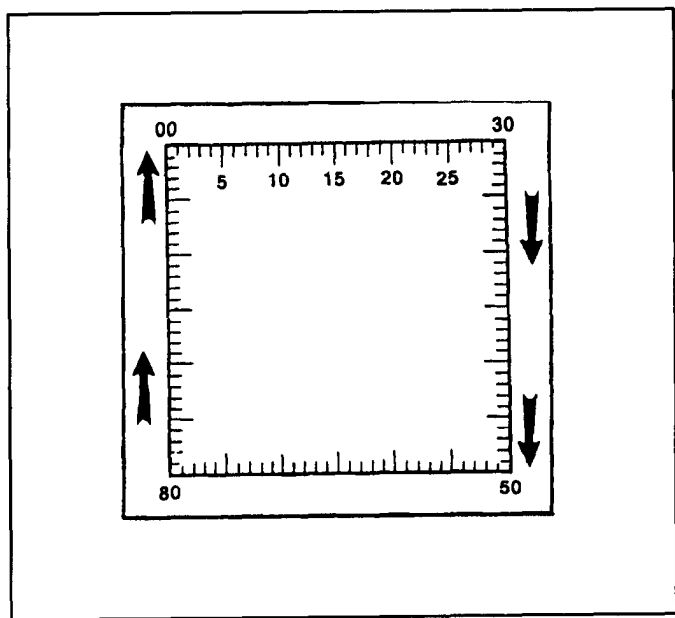


Figure 9-2. Border coordinates.

Border coordinates are constructed on the chart so that 00 through 30 are located on the top border. The numbers 30 through 50 are located on the right border. The bottom border contains 50 through 80. And 80 through 100 are located on the left border. The spaces between the tick marks can be mechanically interpolated into tenths (Figure 9-3).

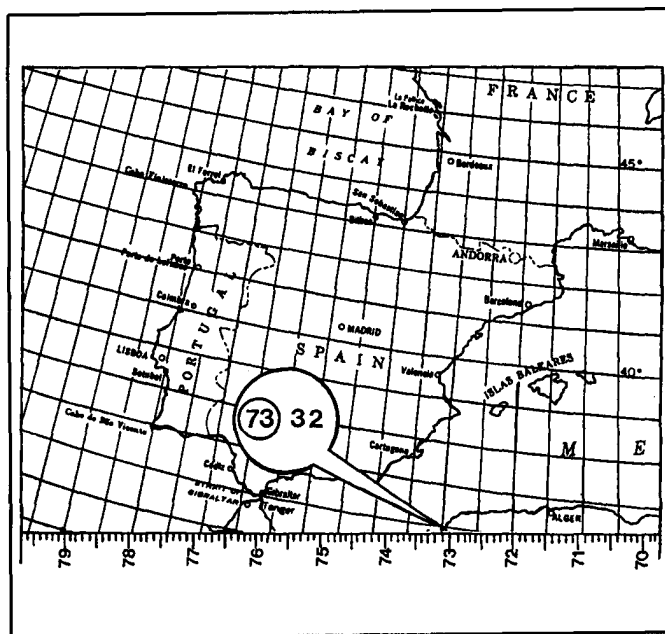


Figure 9-3. Bottom border coordinates.

This provides a total of 10,000 coordinates for plotting purposes (Figure 9-4).

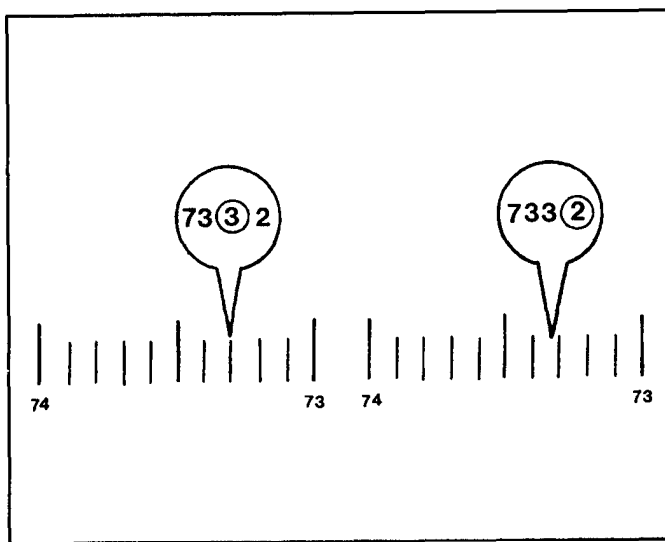


Figure 9-4. Interpolation.

Tables are constructed for each DF site, providing coordinates for all azimuths. When a bearing is reported by a DF site, it is converted to border coordinates. It is then plotted on the gnomonic chart by drawing a line between the coordinate and the DF site. Border coordinates and conversion tables are machine computed. They may be obtained on request from the National Security Agency/Central Security Service. The applicable gnomonic chart number and the exact latitude and longitude of each DF site located must be included in the request.

Corrected Compass Rose

A corrected compass rose is nothing more than a compass rose which has been corrected or expanded to compensate for angular distortion. In other words, the degree marks have been placed close together or moved apart. This is done according to the amount of map distortion present (Figure 9-5).

When situated on the gnomonic plotting chart, the CCR must have its center exactly over the DF site location. Bearings can then be plotted from the CCR. If desired, the rose can be extended to a line around the edge of the map. This is accomplished in the same manner as border coordinates. A corrected compass rose is constructed using the right-triangle method.

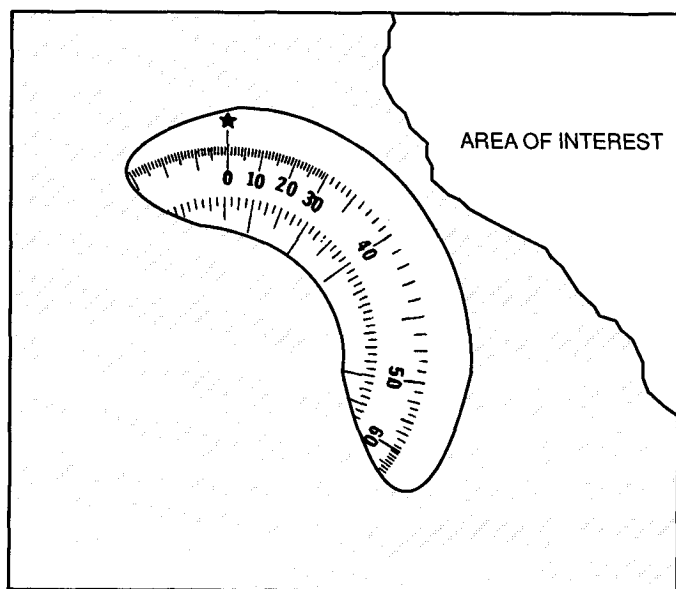


Figure 9-5. Corrected compass rose.

Right-Triangle Method. Constructing a CCR by the right-triangle method entails the computation of mathematical formulas. It is time consuming. However, this is compensated by the high degree of accuracy and reliability it provides. Since radio waves follow great circle paths, the right-triangle method of error correction is concerned with spherical trigonometry. Under theoretical conditions, the equator and the selected meridian would intersect at a right angle (Figure 9-6).

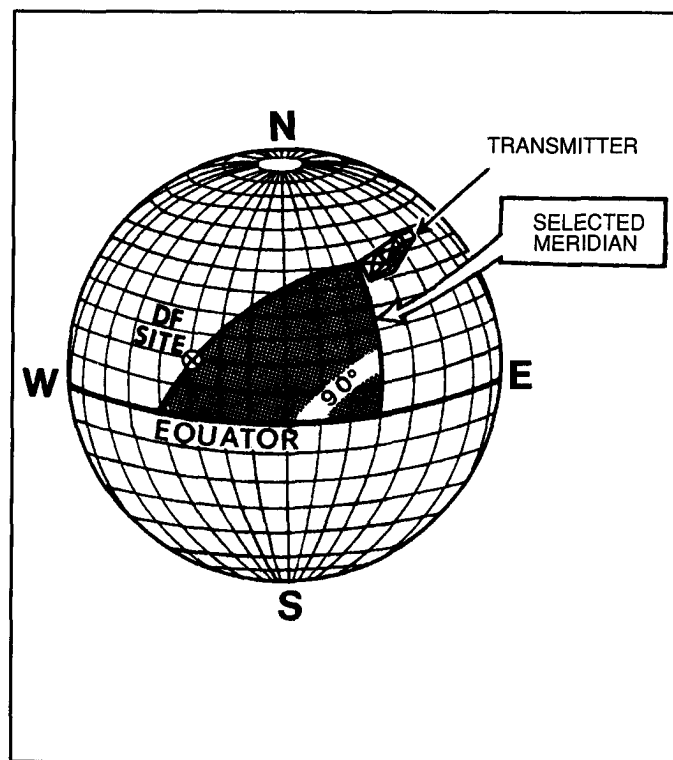


Figure 9-6. Spherical right triangle.

The azimuth from the DF site would intersect both the equator and the selected meridian. This forms a right triangle. A common logarithm of functions of angles in degrees and minutes table (Appendix A) is used to solve the unknown quantities of a spherical right triangle. For additional information on the principles and application of logarithms, refer to TM 11-684. The three known factors of the computation are the—

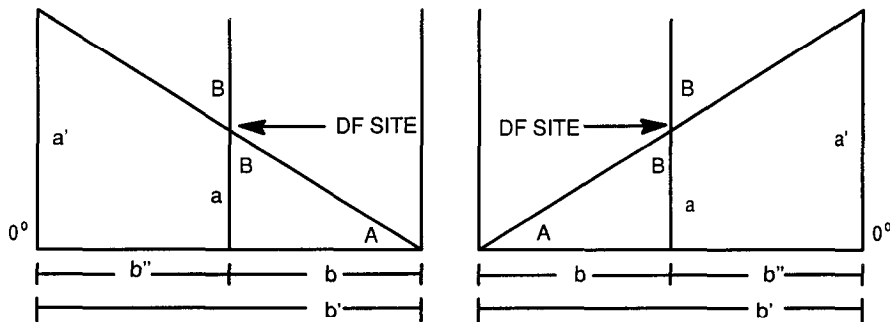
- Latitude and longitude of the DF site.
- Longitude of the selected meridian.
- Desired azimuth.

Right-Triangulation Computation Work Sheet. The selected meridian used during the computation should be in the approximate center of the area of interest. It also should be noted that one single meridian need not be

used for the computation of the entire CCR. Figure 9-7 illustrates the formula used in the right-triangle method of computation.

NOTE

The use of a calculator containing logarithmic/trigonometric functions would decrease the time needed to construct CCR. However, for instructional purposes, the tables contained in Appendix A are used.



$B =$ _____ $a =$ _____ $b'' =$ _____ $b =$ _____
 $a' =$ _____ $A =$ _____ $b' =$ _____

$$(\log \tan b) = (\log \sin a) - (\log \cot B)$$

$\log \sin a:$ _____

$\log \cot B:$ _____

Diff: _____ = $\log \tan b$

$b =$ _____

$$(\log \cos A) = (\log \cos a) + (\log \sin B)$$

$\log \cos a:$ _____

$\log \sin B:$ _____

Sum: _____ = $\log \cos A$

$A =$ _____

$$(\log \tan a') = (\log \sin b') - (\log \cot A)$$

$\log \sin b':$ _____

$\log \cot A:$ _____

Diff: _____ = $\log \tan a'$

$a' =$ _____

Figure 9-7. Right-triangle computation work sheet.

An explanation of the right-triangle computation work sheet is as follows:

- The bottom line, marked 0 degrees, represents the equator.
- Line a is the distance in degrees and minutes from the equator to the DF site or the latitude of the site.
- Angle B is the desired azimuth which is to be corrected for angular map distortion.
- Angle A is the angle the desired azimuth makes at the equator.

Note: Angles A and B do not total 90 degrees as in a true right triangle. This is because the right-triangle method deals with a right triangle only in theory. The functions are computed by spherical trigonometry.

- Line b is the distance in degrees and minutes of the difference in longitude between the DF site and the intersection of the azimuth with the equator.
- Line b" is the distance in degrees and minutes from the DF site to the selected meridian.
- Line b' is the difference in longitude of the intersection of the azimuth with the equator and the selected meridian. (Line b' is the sum of lines b and b".)

- The value of a' represents the latitude at which the bearing will intersect the selected meridian.

Common Logarithms of Functions of Angles in Degrees and Minutes Table. The table is used in solving the unknown quantities of a spherical right triangle. This information is used to construct a corrected compass rose. The use of common logarithms of functions of angles in degrees and minutes table is as follows:

- **Degrees.** Each page of the table in Appendix A is computed for eight different angles. Four are indicated in the upper left corner and four in the lower right corner. The fact that one page is sufficient for the functions of eight different angles is a result of the properties of trigonometric functions. For example, the sine of 0 degrees is numerically equal to the sine of 180 degrees. The cosine of 90 degrees is equal to the cosine of 270 degrees (Figure 9-8).
- **Minutes.** The minutes for each angle are found in the columns headed by the mathematical sign for minutes (') (Figure 9-9, page 9-6).

0°..180°		L SIN	D	L TAN	CD	L COT	L COS	
90°..270°		L COS		L COT		L TAN	L SIN	
	0	—		—		—	0.00 000	60
	1	6.46 373	30103	6.46 373	30103	3.53 627	0.00 000	59
	2	6.76 476		6.76 476	17609	3.23 524	0.00 000	58
	3	6.94 085		6.94 085	12494	3.05 915	0.00 000	
	4			6.94 085	9691	2.93 421		

	59	8.21 958	769	8.21 958	756	1.77 280	9.99 994	5
	58	8.22 713	755	8.22 720	742	1.76 538	9.99 994	4
	57	8.23 456	743	8.23 462	730	1.75 808	9.99 994	3
	56	8.24 186	730	8.24 192			9.99 993	2
								1
								0

	L SIN	D	L TAN	CD	L COT	L COS		359°..179°
	L COS		L COT		L TAN	L SIN		269°..89°

Figure 9-8. Properties of trigonometric functions.

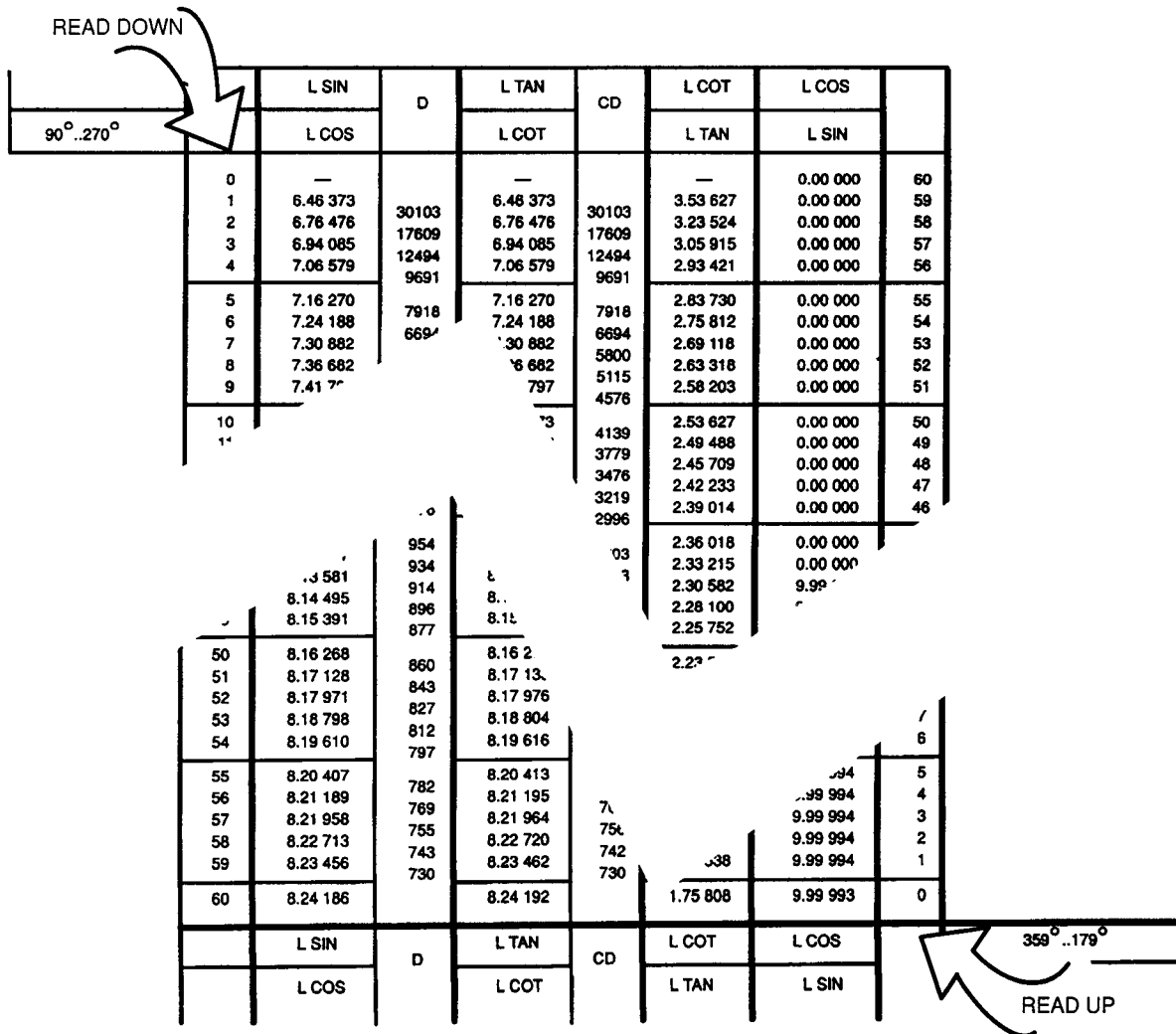


Figure 9-9. Minutes.

The minutes for the angles in the upper left corner are read *down* the left minute column. The minutes for the angles in the lower right corner are read *up* the right

use the following steps (Figure 9-10):

- STEP 1.** Locate the page containing the angle of the trigonometric function (Figure 9-10 (1)).
- STEP 2.** Follow the angle's minute column either up or down until the exact minute reading is located (Figure 9-10 (2)).

STEP 3. Determine which function is appropriate by consulting the legend. Check both the top and the bottom of the table (Figure 9-10 ③). Angle functions are *opposite* each angle or degree reading. The number found at the intersection of the function column and the logarithm row opposite the minute column is the logarithm of that angle.

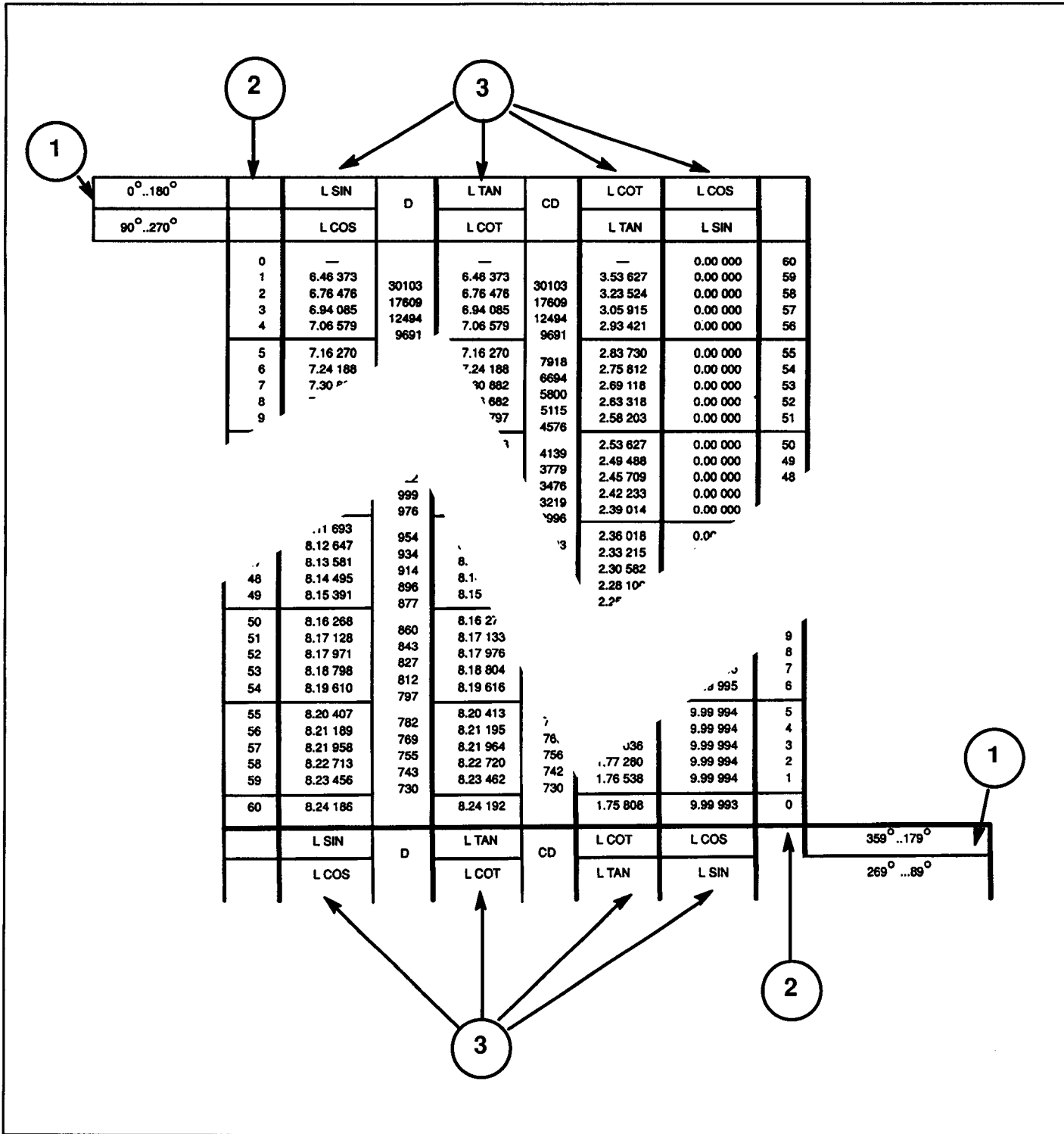


Figure 9-10. Use of the tables.

To determine the angle of a logarithm, use the following steps (Figure 9-11):

STEP 1. Locate the logarithm which is *nearest* the given logarithm in the appropriate function column (Figure 9-11 (1)).

STEP 2. The minute value will be selected from either the corresponding number in the left minute column or the right minute column (Figure 9-11 (2)).

STEP 3. Note the corresponding angles of the function column, top left corner and bottom right corner. Select the *lowest* of the four angles (Figure 9-11 (3)). If the selected angle is at the top of the page, read the minute value from the left minute column. However, if the selected angle is taken from the bottom of the page, read the minute value from the right minute column.

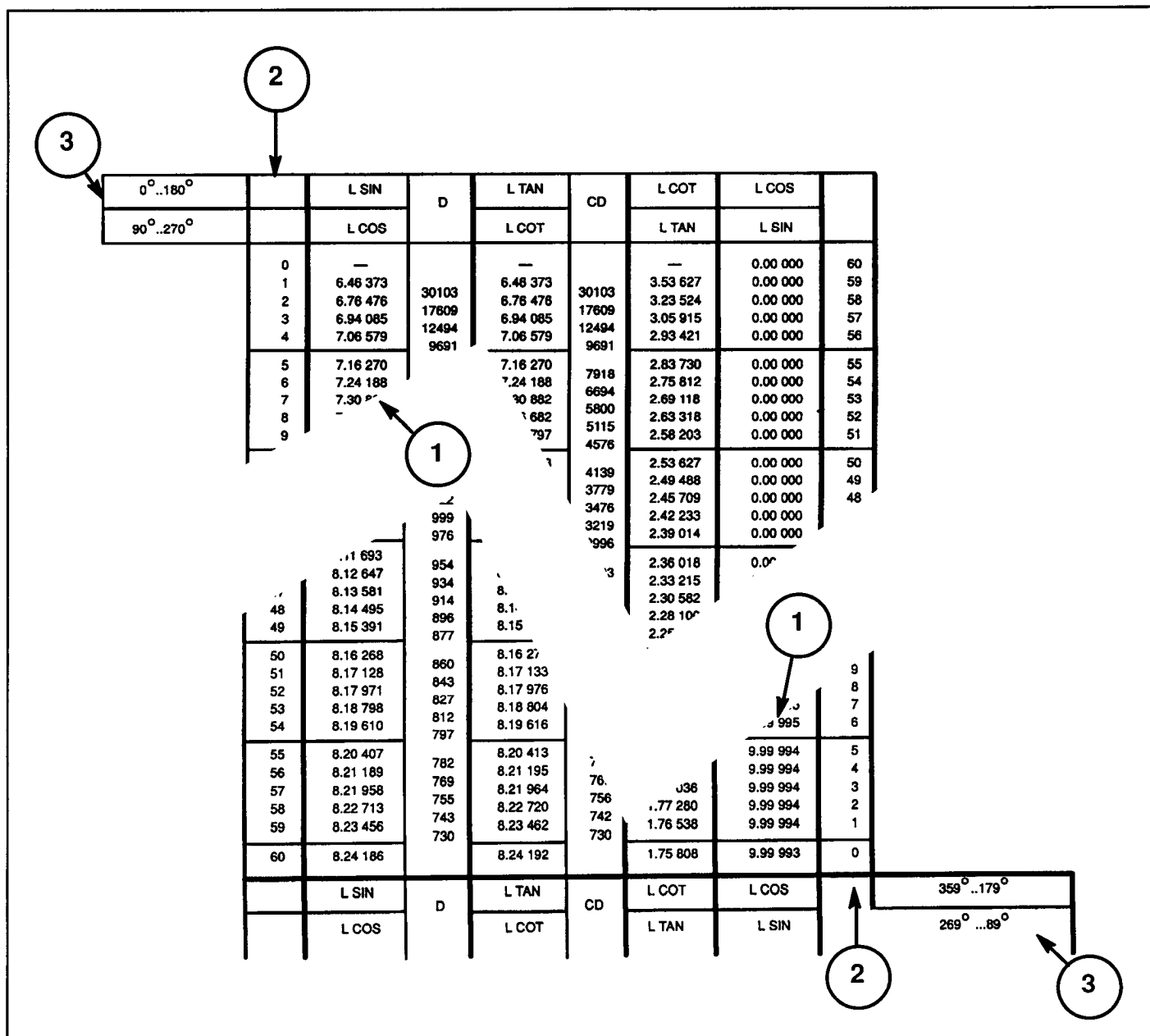


Figure 9-11. Determining the angle of a logarithm.

Right-Triangle Method Example. The desired azimuth (or angle B) which is to be corrected for angular distortion is 10 degrees. The latitude of the DF site (or line a) is 36 degrees. The difference in longitude between the DF site and selected meridian (or b“) is 5 degrees. (Refer to Appendix A for logarithm table.)

STEP 1. Find b:

$$(\log \sin a) - (\log \cot B) = (\log \tan b)$$

$$\log \sin 36 \text{ degrees} = 9.76922-10 \text{ (Figure 9-12)}$$

$$\log \cot 10 \text{ degrees} = 0.75368 \text{ (Figure 9-13)}$$

36°...216°		L SIN	D	L TAN	CD	L COT	L COS	D	
126°...306°		L COS		L COT		L TAN	L SIN		
	0	9.76 922	17	9.86 126	27	0.13 874	9.90 796	9	60
		9.76 939	18	9.86 153	26	0.13 847	9.90 787	10	59
		9.76 957	17	9.86 179	27	0.13 821	9.90 777	9	58
		9.76 974	17	9.86 206	26	0.13 794	9.90 768	9	57
	4	9.76 991	18	9.86 232	27	0.13 768	9.90 759	9	56
	5	9.77 009	17	9.86 259	26	0.13 741	9.90 750	9	55
	6	9.77 026	17	9.86 285	27	0.13 715	9.90 741	10	54
	7	9.77 043	18	9.86 312	26	0.13 688	9.90 731	9	53
	8	9.77 061	17	9.86 338	27	0.13 662	9.90 722	9	52
	9	9.77 078	17	9.86 365	27	0.13 635	9.90 713	9	51

Figure 9-12. Log sin 36 degrees.

10°...190°		L SIN	D	L TAN	CD	L COT	L COS	
100°...280°		L COS		L COT		L TAN	L SIN	
	0	9.23 967	72	9.24 632	74	0.75 368	9.99 335	60
	1	9.24 039	71	9.24 706	73	0.75 294		59
	2	9.24 110	71	9.24 779	74	0.75 221		58
	3	9.24 181	72	9.24 853	73	0.75 147		
	4	9.24 253	71	9.24 926	74	0.75 074	9.99 326	
	5	9.24 324	71	9.25 000	73	0.75 000	9.99 324	55
	6	9.24 395	71	9.25 073	73	0.74 927	9.99 322	54
	7	9.24 466	70	9.25 146	73	0.74 854	9.99 319	53
	8	9.24 536	71	9.25 219	73	0.74 781	9.99 317	52
	9	9.24 607	70	9.25 292	73	0.74 708	9.99 315	51

Figure 9-13. Log cot 10 degrees.

Log diff = 9.01554-10

Log tan b = 9.01554-10

b = 5 degrees 55 minutes (Figure 9- 14)



5° ..185°		L SIN	D	L TAN	CD	L COT	L COS	
95° ..275°		L COS		L COT		L TAN	L SIN	
0	8.94 030	144	8.94 195	145	1.05 805	9.99 834	60	
1	8.94 174	143	8.94 340	145	1.05 660	9.99 833	59	
2	8.94 317	144	8.94 458	145	1.05 515	9.99 832	58	
3	8.94 461	142	8.94 630	143	1.05 370	9.99 831	57	
4	8.94 603	143	8.94 773	144	1.05 227	9.99 830	56	
5	8.94 746	141	8.94 917	143	1.05 083	9.99 829	55	
6	8.94 887	142	8.95 060	142	1.04 940	9.99 828	54	
7	8.95 029	141	8.95 202	142	1.04 798	9.99 827	53	
8	8.95 170	140	8.95 344	142	1.04 656	9.99 825	52	
9	8.95 310	140	8.95 486	142	1.04 514	9.99 824	51	
10	8.95 450	139	8.95 627	141	1.04 373	9.99 823	50	
11	8.95 589	139	8.95 768	140		9.99 822	49	
12	8.95 728	139				9.99 821	48	
13	8.95 867	138				9.99 820	47	
14	8.96 005	138					46	
15	8.96 143	126	8.96 281	129	1.00 241		45	
16	8.96 281	126	8.96 419	128	1.00 081			
17		126	8.96 557	127	0.99 954			
18		126	8.96 695	127	0.99 826	9.99 826		
19		125	8.96 833	126	0.99 699	9.99 781		
20		125	8.96 971	126	0.99 573	9.99 780		
21		124	8.97 109	126	0.99 447	9.99 778	13	
22		125	8.97 247	126	0.99 321	9.99 777	12	
23		125	8.97 385	126	0.99 195	9.99 776	11	
24		123	8.97 523	125				
25		124	8.97 661	125	0.99 070	9.99 775	10	
26		123	8.97 799	124	0.98 945	9.99 773	9	
27		123	8.97 937	124	0.98 821	9.99 772	8	
28		122	8.98 075	124	0.98 697	9.99 771	7	
29		122	8.98 213	123	0.98 573	9.99 769	6	
30		122	8.98 351	123	0.98 450	9.99 768	5	
31		121	8.98 489	122	0.98 327	9.99 767	4	
32		121	8.98 627	122		9.99 765	3	
33		121	8.98 765	122		9.99 764	2	
34		120	8.98 903	122		9.99 763	1	
35		120	8.99 041	122			0	
36		120	8.99 179	122				
37		120	8.99 317	122				
38		120	8.99 455	122				
39		120	8.99 593	122				
40		120	8.99 731	122				
41		120	8.99 869	122				
42		120	8.99 907	122				
43		120	9.00 045	122				
44		120	9.00 183	122				
45		120	9.00 321	122				
46		120	9.00 459	122				
47		120	9.00 597	122				
48		120	9.00 735	122				
49		120	9.00 873	122				
50		120	9.01 011	122				
51		120	9.01 149	122				
52		120	9.01 287	122				
53		120	9.01 425	122				
54		120	9.01 563	122				
55		120	9.01 701	122				
56		120	9.01 839	122				
57		120	9.01 977	122				
58		120	9.02 115	122				
59		120	9.02 253	122				
60		120	9.02 391	122				
61		120	9.02 529	122				
62		120	9.02 667	122				
63		120	9.02 805	122				
64		120	9.02 943	122				
65		120	9.03 081	122				
66		120	9.03 219	122				
67		120	9.03 357	122				
68		120	9.03 495	122				
69		120	9.03 633	122				
70		120	9.03 771	122				
71		120	9.03 909	122				
72		120	9.04 047	122				
73		120	9.04 185	122				
74		120	9.04 323	122				
75		120	9.04 461	122				
76		120	9.04 599	122				
77		120	9.04 737	122				
78		120	9.04 875	122				
79		120	9.05 013	122				
80		120	9.05 151	122				
81		120	9.05 289	122				
82		120	9.05 427	122				
83		120	9.05 565	122				
84		120	9.05 703	122				
85		120	9.05 841	122				
86		120	9.05 979	122				
87		120	9.06 117	122				
88		120	9.06 255	122				
89		120	9.06 393	122				
90		120	9.06 531	122				
91		120	9.06 669	122				
92		120	9.06 807	122				
93		120	9.06 945	122				
94		120	9.07 083	122				
95		120	9.07 221	122				
96		120	9.07 359	122				
97		120	9.07 497	122				
98		120	9.07 635	122				
99		120	9.07 773	122				
100		120	9.07 911	122				
101		120	9.08 049	122				
102		120	9.08 187	122				
103		120	9.08 325	122				
104		120	9.08 463	122				
105		120	9.08 601	122				
106		120	9.08 739	122				
107		120	9.08 877	122				
108		120	9.09 015	122				
109		120	9.09 153	122				
110		120	9.09 291	122				
111		120	9.09 429	122				
112		120	9.09 567	122				
113		120	9.09 705	122				
114		120	9.09 843	122				
115		120	9.09 981	122				
116		120	9.10 119	122				
117		120	9.10 257	122				
118		120	9.10 395	122				
119		120	9.10 533	122				
120		120	9.10 671	122				
121		120	9.10 809	122				
122		120	9.10 947	122				
123		120	9.11 085	122				
124		120	9.11 223	122				
125		120	9.11 361	122				
126		120	9.11 499	122				
127		120	9.11 637	122				
128		120	9.11 775	122				
129		120	9.11 913	122				
130		120	9.12 051	122				
131		120	9.12 189	122				
132		120	9.12 327	122				
133		120	9.12 465	122				
134		120	9.12 603	122				
135		120	9.12 741	122				
136		120	9.12 879	122				
137		120	9.13 017	122				
138		120	9.13 155	122				
139		120	9.13 293	122				
140		120	9.13 431	122				
141		120	9.13 569	122				
142		120	9.13 707	122				
143		120	9.13 845	122				
144		120	9.13 983	122				
145		120	9.14 121	122				
146		120	9.14 259	122				
147		120	9.14 397	122				
148		120	9.14 535	122				
149		120	9.14 673	122				
150		120	9.14 811	122				
151		120	9.14 949	122				
152		120	9.15 087	122				
153		120	9.15 225	122				
154		120	9.15 363	122				
155		120	9.15 501	122				
156		120	9.15 639	122				
157		120	9.15 777	122				
158		120	9.15 915	122				
159		120	9.16 053	122				
160		120	9.16 191	122				
161		120	9.16 329	122				
162		120	9.16 467	122				
163		120	9.16 605	122				
164		120	9.16 743	122				
165		120	9.16 881	122				
166		120	9.17 019	122				
167		120	9.17 157	122				
168		120	9.17 295	122				
169		120	9.17 433	122				
170		120	9.17 571	122				
171		120	9.17 709	122				
172		120	9.17 847	122				
173		120	9.17 985	122				
174		120	9.18 123	122				
175		120	9.18 261	122				
176		120	9.18 399	122				
177		120	9.18 537	122				
178		120	9.18 675	122				
179		120	9.18 813	122				
180		120	9.18 951	122				
181		120	9.19 089	122				
182		120	9.19 227	122				
183		120	9.19 365	122				
184		120	9.19 503	122				
185		120	9.19 641	122				
186		120	9.19 779	122				
187		120	9.19 917	122				
188		120	9.20 055	122				
189		120	9.20 193	122				
190		120	9.20 331	122				
191		120	9.20 469	122				
192		120	9.20 607	122				
193		120	9.20 745	122				
194		120	9.20 883	122				
195		120	9.21 021	122				
196		120	9.21 159	122		</		

STEP 2. Find b' :

$$(b'') + (b) = (b')$$

$$b'' = 5 \text{ degrees}$$

$$b = 5 \text{ degrees } 55 \text{ minutes}$$

$$b' = 10 \text{ degrees } 55 \text{ minutes}$$

STEP 3. Find A:

$$(\log \cos a) + (\log \sin B) = (\log \cos A)$$

$$\log \cos 36 \text{ degrees} = 9.90796-10 \text{ (Figure 9-15)}$$

$$\log \sin 10 \text{ degrees} = 9.23967-10 \text{ (Figure 9-16)}$$

NOTE: Always select the lowest degree and minute reading.

36°...216°		L SIN	D	L TAN	CD	L COT	L COS	D	
126°...306°		L COS		L COT		L TAN	L SIN		
	0	9.76 922	17	9.86 126	27	0.13 874	9.90 796	9	60
	1	9.76 939	18	9.86 153	26	0.13 847	9.90 787	10	59
	2	9.76 957	17	9.86 179	27	0.13 821	9.90 777	9	58
	3	9.76 974	17	9.86 206	26	0.13 794	9.90 768	9	57
	4	9.76 991	18	9.86 232	27	0.13 768	9.90 759	9	56
	5	9.77 009	17	9.86 259	26	0.13 741	9.90 750	9	55
	6	9.77 026	17	9.86 285	27	0.13 715	9.90 741	10	54
	7	9.77 043	18	9.86 312	26	0.13 688	9.90 731	9	53
	8	9.77 061	17	9.86 338	27	0.13 662	9.90 722	9	52
	9	9.77 078	17	9.86 365	27	0.13 635	9.90 713	9	51

Figure 9-15. Log cos 36 degrees.

10°...190°		L SIN	D	L TAN	CD	L COT	L COS	
100°...280°		L COS		L COT		L TAN	L SIN	
	0	9.23 967	72	9.24 632	74	0.75 368	9.99 335	60
		9.24 039	71	9.24 706	73	0.75 294	9.99 333	59
		9.24 110	71	9.24 779	74	0.75 221	9.99 331	58
	3	9.24 181	72	9.24 853	73	0.75 147	9.99 328	57
	4	9.24 253	71	9.24 926	74	0.75 074	9.99 326	56
	5	9.24 324		9.25 000		0.75 000	9.99 324	55
	6	9.24 395	71	9.25 073	73	0.74 927	9.99 322	54
	7	9.24 466	71	9.25 146	73	0.74 854	9.99 319	53
	8	9.24 536	70	9.25 219	73	0.74 781	9.99 317	52
	9	9.24 607	71	9.25 292	73	0.74 708	9.99 315	51

Figure 9-16. Log sin 10 degrees.

Log sum = 19.14763-20
Log cos A = 9.14763-10 (Figure 9-17)
A = 81 degrees 55 minutes

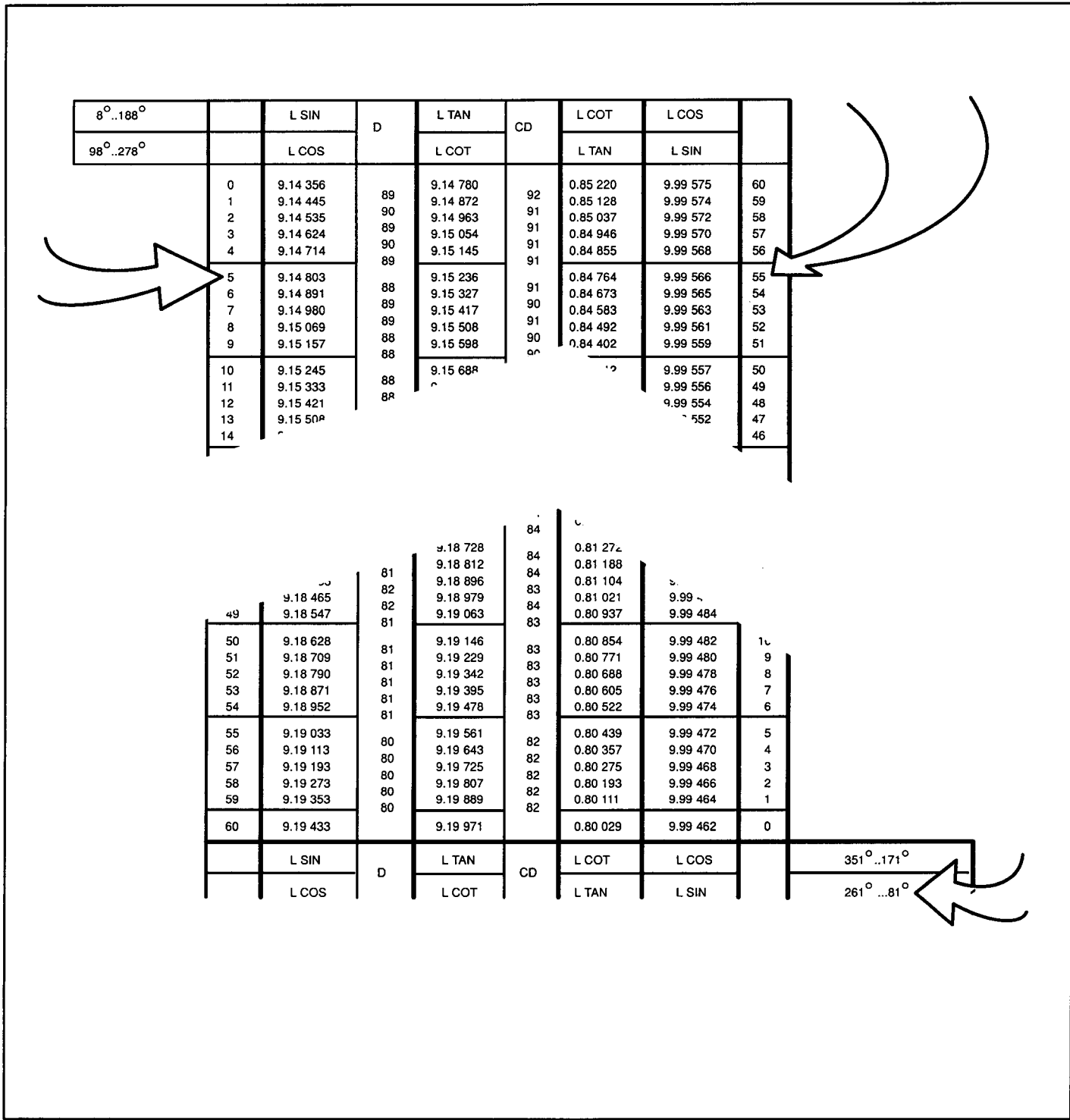


Figure 9-17. Determining the angle of log cos 9.14763-10.

Log diff = 0.12498
Log tan a' = 0.12498
a' = 53 degrees 08 minutes
(Figure 9-20)

STEP 5. A straightedge aligned with 53 degrees and 8 minutes latitude on the selected meridian indicates the corrected azimuth for 10 degrees. When constructing a corrected compass rose, a tick mark should be placed on the compass rose and numbered 10 degrees. Or a tick mark should be placed on the edge of the plotting chart and numbered 10 degrees.

A problem area may arise when computing desired azimuths around 90 or 270 degrees. To eliminate confusion, subtract the value of b from

90 degrees and complete the computations. This procedure should also be used approximately 5 degrees on either side of the 90 or 270 degree azimuth. This ensures standard accuracy.

NOTE: It is apparent that logarithm tables are constructed in such a manner so the area from 0 to 90 degrees represents the entire 360 degrees. Any computation using X degrees east as the selected meridian will also be correct for X degrees west and both reciprocals. Therefore, any single computation will yield four azimuths. Ninety computations are required to complete the entire compass rose.

40	9.77 609	17	9.87 185	26	0.12 815	9.90 424	9	20
41	9.77 626	17	9.87 211	27	0.12 789	9.90 415	10	19
42	9.77 643	17	9.87 238	26	0.12 762	9.90 405	9	18
43	9.77 660	17	9.87 264	26	0.12 736	9.90 396	10	17
44	9.77 677	17	9.87 290	27	0.12 710	9.90 386	9	16
45	9.77 694	17	9.87 317	26	0.12 683	9.90 377	9	15
46	9.77 711	17	9.87 343	26	0.12 657	9.90 368	10	14
47	9.77 728	17	9.87 369	27	0.12 631	9.90 358	9	13
48	9.77 744	16	9.87 396	26	0.12 604	9.90 349	10	12
49	9.77 761	17	9.87 422	26	0.12 578	9.90 339	9	11
50	9.77 778	17	9.87 448	27	0.12 552	9.90 330	10	10
51	9.77 795	17	9.87 475	26	0.12 525	9.90 320	9	9
52	9.77 812	17	9.87 501	26	0.12 499	9.90 311	10	8
53	9.77 829	17	9.87 527	27	0.12 473	9.90 301	9	7
54	9.77 846	16	9.87 554	26	0.12 446	9.90 292	10	6
55	9.77 862	17	9.87 580	26	0.12 420	9.90 282	9	5
56	9.77 879	17	9.87 606	27	0.12 394	9.90 273	10	4
57	9.77 896	17	9.87 633	26	0.12 367	9.90 263	9	3
58	9.77 913	17	9.87 659	26	0.12 341	9.90 254	10	2
59	9.77 930	16	9.87 685	26	0.12 315	9.90 244	9	1
60	9.77 946		9.87 711		0.12 289	9.90 235		0
	L SIN	D	L TAN	CD	L COT	L COS	D	323° ... 143°
	L COS		L COT		L TAN	L SIN		233° ... 53°

Figure 9-20. Log tan a' 0.12498 angle.

GREAT CIRCLE AZIMUTH AND DISTANCE

Radio waves follow great circle paths between the transmitting and receiving antennas. When the exact location of the signal source is known, it is possible to compute the true or great circle azimuth and distance (GCAD). This can be computed from the point of signal origin to any other point receiving the signal on the surface of the earth. The computations of great circle

azimuths are based on spherical trigonometry (Figure 9-21). They may be computed using the dead-reckoning altitude and azimuth table in Appendix B. This method is simpler and much faster than using other logarithmic methods. It is accurate to within one half a minute. Greater accuracy is possible by interpolating between table functions.

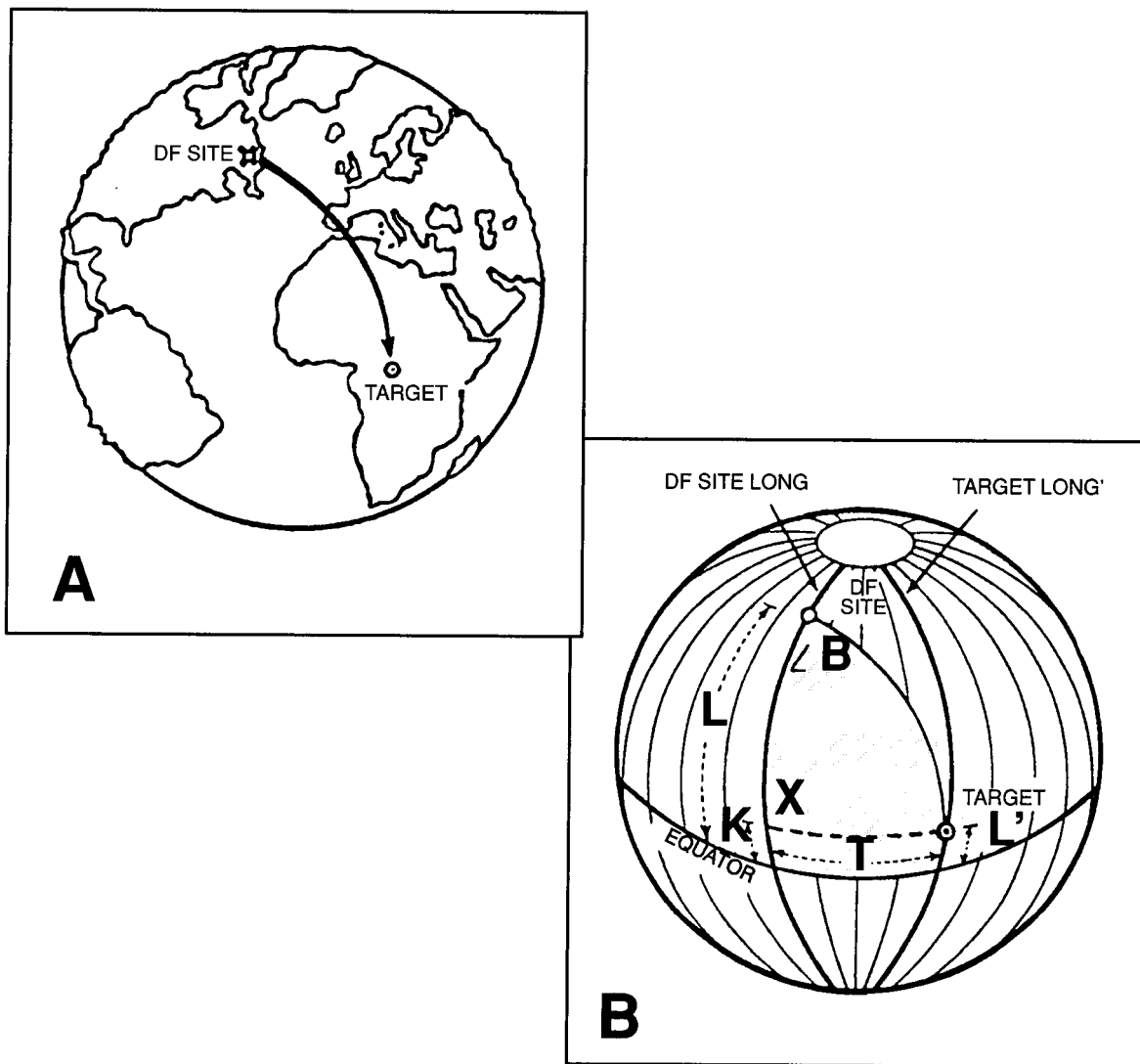


Figure 9-21. Spherical trigonometry.

Dead-Reckoning Altitude and Azimuth Table

The dead-reckoning altitude and azimuth table (Figure 9-22) is arranged in parallel A and B columns. The A columns contain log cosecants multiplied by 100,000. The B columns contain log secants also multiplied by 100,000. The A columns decrease in value from the front of the table toward the rear. The B

columns increase in value from the front of the table to the rear.

When determining degrees and minutes from the top of the table, read the minutes from the *left* column (Figure 9-22 ①). However, when reading the degrees and minutes from the bottom of the table, read the minutes from the *right* column (Figure 9-22 ②). If the desired degrees and minutes exceed 180 degrees, subtract 180 degrees before entering the table.

	0°00'		0°30'		1°00'		1°30'		2°00'		
	A	B	A	B	A	B	A	B	A	B	
0	0.0		205916.....1.7		175814.....6.6		158208.....14.9		145718.....26.5		30
	383730.....0.0		205198.....1.7		175454.....6.7		157967.....15.1		145538.....26.7		
1	353627.....0.0		204492.....1.8		175097.....6.8		157728.....15.2		145358.....26.9		29
	336018.....0.0		203797.....1.8		174742.....7.0		157490.....15.4		145179.....27.1		
2	323524.....0.0		203113.....1.9		174391.....7.1		157254.....15.6		145000.....27.3		28
	313833.....0.0		202440.....1.9		174042.....7.2		157019.....15.7		144823.....27.6		
3	305915.....0.0		201777.....2.0		173696.....7.3		156784.....15.9		144646.....27.8		27
	299221.....0.0		201124.....2.1		173352.....7.4		156552.....16.1		144470.....28.0		
4	293421.....0.0		200480.....2.1		173012.....7.5		156320.....16.2		144295.....28.3		26
	288306.....0.0		199846.....2.2		172674.....7.6		156090.....16.4		144120.....28.5		
5	283730.....0.0		199221.....2.3		172339.....7.8		155861.....16.6		143946.....28.7		25
	279591.....0.1		198605.....2.3		172006.....7.9		155633.....16.8		143773.....28.9		
6	275812.....0.1		197998.....2.4		171676.....8.0		155406.....16.9		143600.....29.2		24
	272336.....0.1		197399.....2.4		171348.....8.1		155180.....17.1		143428.....29.4		
7	269118.....0.1		196808.....2.5		171023.....8.2		154956.....17.3		143257.....29.6		23
	266121.....0.1		196225.....2.6		170694.....8.4		154733.....17.5		143086.....29.9		
8	263318.....0.1						154511.....17.6		142916.....30.1		22
							154290.....17.8				
.....											
					161463.....12.0				153000.....17.9		
24	215607.....1.1		180390.....5.4		161204.....13.0		147945.....23.9		137804.....38.1		6
	214711.....1.1		179990.....5.5		160946.....13.1		147755.....24.1		137653.....38.4		
25	213834.....1.1		179593.....5.6		160690.....13.3		147566.....24.3		137504.....38.6		5
	212974.....1.2		179200.....5.7		160435.....13.4		147377.....24.5		137354.....38.9		
26	212130.....1.2		178810.....5.8		160182.....13.6		147190.....24.7		137205.....39.2		4
	211303.....1.3		178424.....5.9		159930.....13.8		147003.....24.9		137057.....39.4		
27	210491.....1.3		178042.....6.0		159680.....13.9		146817.....25.2		136909.....39.7		3
	209695.....1.4		177663.....6.1		159431.....14.1		146632.....25.4		136761.....40.0		
28	208912.....1.4		177287.....6.2		159184.....14.2		146448.....25.6		136615.....40.3		2
	208143.....1.5		176914.....6.3		158938.....14.4		146264.....25.8		136468.....40.5		
29	207388.....1.5		176544.....6.4		158693.....14.6		146081.....26.0		136322.....40.8		1
	206646.....1.6		176178.....6.5		158450.....14.7		145899.....26.2		136177.....41.1		
30	205916.....1.7		175814.....6.6		158208.....14.9		145718.....26.5		136032.....41.4		0
	A B		A B		A B		A B		A B		
	179°30'		179°00'		178°30'		178°00'		177°30'		

Figure 9-22. Dead-reckoning altitude and azimuth table.

Great Circle Azimuth and Distance Computation

Great circle azimuth and distance computations are based on spherical trigonometry. A terrestrial triangle has curved sides and is commonly referred to as a

spherical triangle. Refer to Figure 9-21 (B), page 9-15. The shaded portion of the illustration is a spherical triangle. The determination of the true azimuth and distance is reduced to simply completing the work sheet (Figure 9-23) using the dead-reckoning altitude and azimuth table.

FROM: _____	TO: _____	T is determined by the following conditions: If long and long' are the same name SUBTRACT. If long and long' are different names ADD.
LAT: _____	LAT': _____	
LONG: _____	LONG': _____	T _____

DEGREES/MINUTES	COL-1 (ADD)	COL-2 (SUBTRACT)	COL-3 (ADD)	COL-4 (SUBTRACT)
T: _____	A: _____			
L': _____	B: _____	A: _____		
	A: _____	B: _____	B: _____	A: _____
K: _____		A: _____		
L: _____				
 KL: _____			B: _____	
D ARC: _____			B: _____	A: _____
 60 x DEGREES _____				A: _____
+ MINUTES + _____				<8 _____
TOTAL _____				
TRUE AZIMUTH _____				

If other logarithm tables are used instead of dead-reckoning altitude and azimuth tables, column A equates to log cosecant, and column B equates to log secant.

Figure 9-23. GCAD computation work sheet.

Specific formula symbols used in the GCAD formula (Figure 9-24) are as follows:

- L or lat is the latitude of the initial position or the DF site.
- L' or lat' is the latitude of the final position or the check station.
- $\angle B$ is the great circle azimuth from the check station to the DF site.
- D arc is the great circle distance, in minutes of arc, between the target and the DF site. (One minute of arc equals one nautical mile.)
- X is the factor introduced to simplify the computation. It represents that point at which a great circle constructed perpendicular to the target's meridian crosses the meridian of the DF site.
- K is the latitude of point X or the arc from X to the equator (assumes the name of the latitude of the final position).
- KL is the difference between K and L.
- Long is the longitude of the DF site.
- Long' is the longitude of the check station.
- T is the distance from the target longitude to the line of longitude of the DF site.

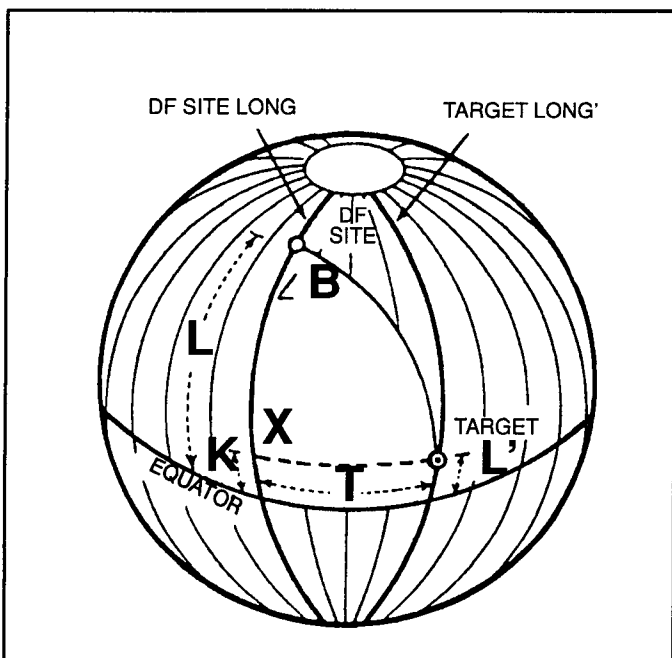


Figure 8-24. Spherical triangle symbols.

Special Rules. The fact that D arc may be greater than 90 degrees has necessitated the following rules:

Rule 1. When L and L' are the same name (north or south), the following procedures are applicable:

- When T is *greater* than 90 degrees, select the K value from the bottom of the dead-reckoning altitude and azimuth table. When T is *less* than 90 degrees, select the K value from the top of the table.
- Record $\angle B$ from the top of the table when K is *greater* than L. When K is *less* than L select $\angle B$ from the bottom of the table.
- D arc is recorded from the top of the table *except* when T and KL are *both greater* than 90 degrees.

Rule 2. When L and L' are different names, the following procedures are applicable:

- When T is *greater* than 90 degrees, select the K value from the bottom of the table. When T is *less* than 90 degrees, select the K value from the top of the table.
- Record $\angle B$ from the bottom of the table *except* when KL is *greater* than 180 degrees.
- D arc is recorded from the bottom of the table *except* when T and KL are *both less* than 90 degrees.
- When KL exceeds 180 degrees, subtract 180 degrees before making a table computation.

Rule 3. Computation of $\angle B$.

- When the initial position is in the *Northern Hemisphere* and is *west* of the final position, $\angle B$ is the true bearing. If the initial position is *east* of the final position, $\angle B$ is subtracted from 360 degrees to obtain the true bearing.
- When the initial position is in the *Southern Hemisphere* and is *west* of the final position, subtract $\angle B$ from 180 degrees. If the initial position is *east* of the final position, add 180 degrees to $\angle B$ to obtain the true bearing.

Great Circle Azimuth and Distance Work Sheet

To facilitate the computation process, a GCAD work sheet is illustrated in Figure 9-25. It is divided into a heading and the step-by-step procedure for determining true azimuth and distance. An explanation of the work sheet and the GCAD formula follows.

The heading contains the latitude and longitude of the direction finding site and the selected check station, containing abbreviations—

- FROM: The name of the DF site.
- LAT or L: The latitude of the DF site.
- LONG: The longitude of the DF site.
- TO: The name of the target station.

- LAT' or L': The latitude of the target station.
- LONG': The longitude of the target station.
- T : To determine T, one of the following two rules is applicable and must be followed.

Rule 1. If LONG and LONG' are in the same hemisphere (same names), *subtract* to determine the T value.

Rule 2. If LONG and LONG' are in different hemispheres (different names), add to determine the T value.

FROM: name of DF site TO: name of Target Station
LAT: DF site Latitude LAT: Target Station Latitude
LONG: DF site Longitude LONG: Target Station Longitude T _____

T is determined by the following conditions: If long and long' are the same name SUBTRACT. If long and long' are different names ADD.

DEGREES/MINUTES	COL-1 (ADD)	COL-2 (SUBTRACT)	COL-3 (ADD)	COL-4 (SUBTRACT)
T: _____	A: _____			
L': _____	B: _____	A: _____		
	A: _____	B: _____	B: _____	A: _____
K: _____		A: _____		
L: _____				
KL: _____			B: _____	
D ARC: _____			B: _____	A: _____
60 X DEGREES _____				A: _____
+ MINUTES _____				< B _____
TOTAL _____				
TRUE AZIMUTH _____				

If other logarithm tables are used instead of dead-reckoning altitude and azimuth tables, column A equates to log cosecant, and column B equates to log secant.

Figure 9-25. GCAD work sheet explanation.

The remainder of the work sheet is divided into the degrees/minutes column and column-1 through column-4. The mathematical function is indicated at the top of each column. Logarithms are entered at the spaces **A** and **B** beginning with column-1 and the appropriate function performed. If other logarithm tables are used instead of the dead-reckoning altitude and azimuth table, column A will equate to the log cosecant. Column B will equate to the log secant. Prior to beginning the computation, enter the T value in the appropriate space under the degrees/minutes column. Complete the work sheet as follows:

COL-1.

- Locate the T value in the dead-reckoning altitude and azimuth table (Appendix B). Enter the figure found under the corresponding A column in the appropriate space under COL-1.
- Enter L' in the appropriate space under the DEGREES/MINUTES column.
- Locate the L' value in the table. Enter the corresponding B column number in the appropriate space under COL-1.
- Add the COL-1 A and B values. Enter the results under the final A space in COL-1.

COL-2.

- Locate the L' value in the table. Enter the corresponding A column figure in the appropriate space under COL-2.
- Locate the COL-1 final A value in the table. Enter the corresponding B figure in the appropriate space under COL-2.
- Subtract the COL-2 B value from the COL-2 A value. The result is entered as the final COL-2 A value.
- Locate the final COL-2 A value in the table. The corresponding degrees and minutes will be entered as the K value under the DEGREES/MINUTES column.

NOTE:

Before the K value is determined, refer to special rules 1 or 2. Determine which rule is applicable to the GCAD computation.

COL-3.

- The first COL-3 B value is a repeat of the COL-2 B value.
- Enter the L or LAT in the appropriate space under the DEGREES/MINUTES column.
- Determine the KL value under the DEGREES/MINUTES column. *Subtract* the L or LAT value from the K value if they are the same name. If they are different names, *add K and L*.
- Locate the KL value in the table. Enter the corresponding B column value in the appropriate COL-3 space.

NOTE:

If rule 2 is applicable to the computation, and the KL value exceeds 180 degrees, subtract 180 degrees before entering the table.

- Add the COL-3 values. Enter the result as the final COL-3 B value.
- Locate the final COL-3 B value in the table. Enter the corresponding degrees and minutes as the D arc value under the DEGREES/MINUTES column.

NOTE:

Refer to applicable rule to determine if the D arc value is taken from the top or the bottom of the table.

COL-4.

- The first COL-4 A value is a repeat of the final COL-1 A value.
- Locate the final COL-3 B value in the table. Enter the corresponding A value **in the appropriate** COL-4 A space.
- Subtract the COL-4 A values and enter the difference in the space provided.
- Locate the final COL-4 A value in the table. Enter the corresponding degrees and minutes as the COL-4 $\angle$ B value.

NOTE:

Again refer to the applicable rule. Determine if $\angle$ B is taken from the top or the bottom of the table. Determine if that value is the true azimuth.

Distance. To compute the great circle azimuth distance—

- Multiply the number of D arc degrees by 60.
- Add the D arc minutes to the result. The sum indicates the distance in nautical miles. To obtain statute miles, multiply the nautical miles by 1.15.

Great Circle Azimuth and Distance Example.

Determine the great circle azimuth and distance from Needham's Villa, USA, to London, England. The necessary coordinates are in Figure 9-26. Before beginning the computation, determine which rule is applicable. Since LONG and LONG' are the same name—west—rule 1 applies.

STEP 1. Determine the T value. Since LONG and LONG' are the same name—west—subtract to find the difference.

Needham's Villa LONG: $71^{\circ} 36'$

London, England LONG': $00^{\circ} 05'$

T $71^{\circ} 31'$

STEP 2. Locate the T value, 71 degrees 31 minutes, in the dead-reckoning altitude and azimuth table. The corresponding COL-1 A value from the table is 2300 (Figure 9-27).

FROM: <u>Needham's Villa</u>	TO: <u>London, England</u>	
LAT: <u>$42^{\circ} 33'$ North</u>	LAT': <u>$51^{\circ} 32'$ North</u>	
LONG: <u>$71^{\circ} 36'$ West</u>	LONG': <u>$00^{\circ} 05'$ West</u>	

T is determined by the following conditions: If long and long' are the same name SUBTRACT. If long and long' are different names ADD.

T $71^{\circ} 31'$

Figure 9-26. Entering initial information on work sheet.

	70°00'		70°30'		71°00'		71°30'		72°00'		
	A	B	A	B	A	B	A	B	A	B	
0	2701.....	46595	2565.....	47650	2433.....	48736	2304.....	49852	2179.....	51002	30
	2699.....	46612	2563.....	47668	2431.....	48754	2302.....	49871	2177.....	51021	
1	2697.....	46630	2561.....	47686	2429.....	48772	2300.....	49890	2175.....	51041	29
	2694.....	46647	2559.....	47704	2427.....	48790	2298.....	49909	2173.....	51060	
2	2692.....	46664	2556.....	47722	2425.....	48808	2296.....	49928	2171.....	51080	28
	2690.....	46682	2554.....	47740	2423.....	48826	2294.....	49947	2169.....	51099	
3	2688.....	46699	2552.....	47758	2420.....	48846	2292.....	49966	2167.....	51119	27
	2685.....	46716	2550.....	47776	2418.....	48864	2290.....	49985	2165.....	51138	
4	2683.....	46734	2548.....	47794	2416.....	48883	2287.....	50004	2163.....	51158	26
	2681.....	46752	2546.....	47812	2413.....	48901	2285.....	50023	2161.....	51177	
5	2679.....	46769	2544.....	47830	2411.....	48920	2283.....	50042	2159.....	51197	25
	2677.....	46787	2542.....	47847	2409.....	48938	2281.....	50061	2157.....	51216	
6	2675.....	46805	2540.....	47865	2407.....	48957	2279.....	50080	2155.....	51236	24

Figure 9-27. A value for 71 degrees 31 minutes.

STEP 3. Locate the L' value, 51 degrees 32 minutes, in the table. The corresponding COL-1 B value is 20617 (Figure 9-28).

A: 2300

B: + 20617

22917

STEP 4. Add COL-1 A and B values (Figure 9-29).
The result or 22917 is the final COL-1 A value.

	50°00'		50°30'		51°00'		51°30'		A	
	A	B	A	B	A	B	A	B		
0	11575....19193		11259....19649		10950....20113		10646....20585		10347....	
	11569....19201		11254....19657		10945....20121		10640....20593		10342....	
1	11564....19208		11249....19664		10939....20128		10635....20601		10337....	
	11559....19216		11244....19672		10934....20136		10630....20609			
2	11553....19223		11239....19680		10929....20144		10625....20617		10327....21098	28
	11548....19231		11233....19687		10924....20152		10620....20625		10322....21106	
3	11543....19238		11228....19695		10919....20160		10615....20633		10317....21114	27
	11537....19246		11223....19703		10914....20167		10610....20641		10312....21122	
4	11532....19253		11218....19710		10909....20175		10605....20649		10307....21131	26
	11527....19261		11213....19718		10904....20183		10600....20657		10302....21139	
5	11522....19269		11207....19726		10899....20191		10595....20665		10298....21147	25
	11516....19276		11202....19733		10894....20199		10590....20672		10293....21155	
6	11511....19284		11197....19741		10888....20207		10585....20680		10288....21163	24
	11506....19291		11192....19749		10883....20214		10580....20688		10283....21171	
7	11501....19299		11187....19756		10878....20222		10575....20696		10278....21179	23
	11495....19306		11181....19764		10873....20230		10570....20704		10273....21187	
8	11490....19314		11176....19772		10868....20238		10565....20712		10268....21195	22
	11485....19321		11171....19779		10863....20246		10560....20720		10263....21204	
9	11479....19329		11166....19787		10858....20254		10555....20728		10258....21212	21
	11474....19337		11161....19795		10853....20261		10550....20736		10253....21220	
10	11469....19344		11156....19803		10848....20269		10545....20744		10248....21228	20
	11464....19352		11150....19810		10843....20277		10540....20752		10243....21236	

Figure 9-28. B value for 51 degrees 32 minutes.

DEGREES/MINUTES	COL -1 (ADD)	COL -2 (SUB)	COL -3 (ADD)
T: 71° 31'	A: 2300		
L': 51° 32'	B: 20617		
	A: 22917		
K: _____			
L: _____			

Figure 9-29. Final COL-1 A value.

STEP 5. Locate the L' value, 51 degrees 32 minutes, in the table (Figure 9-30). The corresponding COL-2 A value is 10625.

	50°00'		50°30'		51°00'		51°30'		52°00'		
	A	B	A	B	B		A	B	A	B	
0	11575....19193		11259....19680		10913....20113		10646....20585		10347....21066		30
	11569....19201		11254....19657		10921....20121		10640....20593		10342....21074		
1	11564....19208		11249....19664		10928....20128		10635....20601		10337....21082		29
	11559....19216		11244....19672				10630....20609		10332....21090		
2	11553....19223		11239....19680		10929....20144		10625....20617		10327....21098		28
	11548....19231		11233....19687		10924....20152		10620....20625		10322....21106		
3	11543....10238		11228....19695		10919....20160		10615....20633		10317....21114		27
	11537....19246		11223....19703		10914....20167		10610....20641		10312....21122		
4	11532....19253		11218....19710		10909....20175		10605....20649		10307....21131		26
	11527....19261		11213....19718		10904....20183		10600....20657		10302....21139		
5	11522....19269		11207....19726		10899....20191		10595....20665		10298....21147		25
	11516....19276		11202....19733		10894....20199		10590....20672		10293....21155		
6	11511....19284		11197....19741		10888....20207		10585....20680		10288....21163		24
	11506....19291		11192....19749		10883....20214		10580....20688		10283....21171		
7	11501....19299		11187....19756		10878....20222		10575....20696		10278....21179		23
	11495....19306		11181....19764		10873....20230		10570....20704		10273....21187		
8	11490....19314		11176....19772		10868....20238		10565....20712		10268....21195		22
	11485....19321		11171....19779		10863....20246		10560....20720		10263....21204		
9	11479....19329		11166....19787		10858....20254		10555....20728		10258....21212		21
	11474....19337		11161....19795		10853....20261		10550....20736		10253....21220		
10	11469....19344		11156....19803		10848....20269		10545....20744		10248....21228		20
	11464....19352		11150....19810		10843....20277		10540....20752		10243....21236		
11	11458....19359		11145....19818		10838....20285		10535....20760		10238....21244		19
	11453....19367		11140....19826		10832....20293		10530....20768		10234....21252		
12	11448....19375		11135....19834		10827....20301		10525....20776		10229....21260		18
	11443....19382		11130....19841		10822....20308		10520....20784		10224....21269		
13	11437....19390		11124....19849		10817....20316		10515....20792		10219....21277		17

DEGREES/MINUTES	COL-1 (ADD)	COL-2 (SUBTRACT)	COL-3 (ADD)	COL-4 (SUBTRACT)
T: <u>71° 31'</u>	A: <u>2300</u>			
L': <u>51° 32'</u>	B: <u>20617</u>	A: <u>10625</u>		
	A: <u>22917</u>	B: _____	B: _____	A: _____
K: _____		A: _____		
L: _____				

22	11343....19527	11032....19988	10726....20458	10426....20937	10131....21424	8
	11338....19534	11027....19996	10721....20466	10421....20945	10126....21432	
23	11332....19542	11021....20004	10716....20474	10416....20953	10121....21440	7
	11327....19549	11016....20012	10711....20482	10411....20961	10116....21448	
24	11322....19557	11011....20019	10706....20490	10406....20969	10112....21457	6

Figure 9-30. A value for 51 degrees 32 minutes.

STEP 6. Locate the COL-1 final A value, 22917, in the table (Figure 9-31). The corresponding COL-2 B value is 9292.

A: 10625

B: - 9292

1333

STEP 7. Subtract the COL-2 B value, 9292, from the COL-2 A value—10625. The remainder is 1333 and the final COL-2 A value (Figure 9-32).

	35°00'	35°30'	36°00'	36°30'	37°00'	
	A B	A B	A B	A B	A B	
0	24141.....8663	23605.....8931	23078.....9204	22561.....9482	22054.....9765	30
	24132.....8668	23596.....8936	23069.....9209	22553.....9487	22045.....9770	
1	24123.....8672	23587.....8940	23061.....9213	22544.....9492	22037.....9775	29
	24114.....8677	23578.....8945	23052.....9218	22536.....9496	22029.....9779	
2	24105.....8681	23569.....8949	23043.....9223	22527.....9501	22020.....9784	28
	24096.....8686	23560.....8954	23035.....9227	22519.....9505	22012.....9789	
3	24087.....8690	23551.....8958	23026.....9232	22510.....9510	22003.....9794	27
	24078.....8694	23543.....8963	23017.....9236	22501.....9515	21995.....9798	
4	24069.....8699	23534.....8967	23009.....9241	22493.....9520	21987.....9803	26
	24060.....8703	23525.....8972	23000.....9246	22484.....9524	21978.....9808	
5	24051.....8708	23516.....8976	22991.....9250	22476.....9529	21970.....9813	25
	24042.....8712	23507.....8981	22983.....9255	22467.....9534	21962.....9818	
6	24033.....8717	23498.....8986	22974.....9259	22459.....9538	21953.....9822	24
	24024.....8721	23490.....8990	22965.....9264	22450.....9543	21945.....9827	
7	24015.....8726	23481.....8995	22957.....9269	22442.....9548	21937.....9832	23
	24006.....8730	23472.....8999	22948.....9273	22433.....9552	21928.....9837	
8	23997.....8734	23463.....9004	22939.....9278	22425.....9557	21920.....9841	22
	23988.....8739	23454.....9008	22931.....9282	22416.....9562	21912.....9846	
9	23979.....8743	23446.....9013	22922.....9287	22408.....9566	21903.....9851	21
	23970.....8748	23437.....9017	22913.....9292	22399.....9571	21895.....9856	
10	23961.....8752	23428.....9022	22905.....9296	22391.....9576	21887.....9861	20
	23952.....8757	23419.....9026	22896.....9301	22382.....9581	21878.....9865	
11	23943.....8761	23410.....9031	22887.....9305	22374.....9585	21870.....9870	19
	23934.....8766	23401.....9035	22879.....9310	22366.....9590	21862.....9875	
12	23925.....8770	23392.....9040	22870.....9315	22357.....9595	21853.....9880	18
	23916.....8775	23383.....9045	22862.....9319	22349.....9599	21845.....9885	

Figure 9-31. A value of 22917.

DEGREES/MINUTES	COL-1 (ADD)	COL-2 (SUBTRACT)	COL-3 (SUBTRACT)	COL-4 (SUBTRACT)
T: <u>71° 31'</u>	A: <u>2300</u>			
L: <u>51° 32'</u>	B: <u>20617</u>	A: <u>10625</u>		
	A: <u>22917</u>	B: <u>9292</u>		
K: _____		A: <u>1333</u>		A: _____

Figure 9-32. Final COL-2 A value.

STEP 8. Locate the final COL-2 A value, 1333, in the table. The corresponding degrees and minutes, 75 degrees 52 minutes 30 seconds, represents the K value (Figure 9-33).

NOTE:

Refer to rule 1a to determine if K is selected from the top or the bottom of the table.

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

	75°00'	75°30'	76°00'	76°30'	77°00'	
	A B	A B	A B	A B	A B	
0	1506.....58700	1406.....60140	1310.....61632	1217.....63181	1128.....64791	30
	1504.....58724	1404.....60164	1308.....61658	1215.....63208	1126.....64819	
1	1502.....58748	1403.....60189	1306.....61683	1214.....63234	1125.....64846	29
	1500.....58771	1401.....60213	1305.....61709	1212.....63260	1123.....64873	
2	1499.....58795	1399.....60238	1303.....61734	1211.....63287	1122.....64901	28
	1497.....58818	1398.....60262	1301.....61759	1209.....63313	1120.....64928	
3	1495.....58842	1396.....60287	1300.....61785	1208.....63340	1119.....64956	27
	1494.....58866	1394.....60311	1299.....61810	1206.....63366	1117.....64983	
14	1459.....59366	1360.....60830	1266.....62348	1175.....63925	1087.....65564	16
	1457.....59390	1359.....60855	1264.....62374	1173.....63952	1086.....65592	
15	1455.....59414	1357.....60880	1262.....62400	1171.....63978	1084.....65620	
	1453.....59438	1355.....60904	1260.....62426	1169.....64004	1082.....65646	
19	1439.....59654	1341.....61129	1247.....62659	1157.....64248	1070.....65900	10
	1437.....59679	1340.....61154	1246.....62685	1155.....64275	1069.....65928	
21	1435.....59703	1338.....61179	1244.....62711	1154.....64302	1067.....65957	9
	1434.....59727	1336.....61204	1243.....62737	1152.....64329	1066.....65985	
22	1432.....59751	1335.....61229	1241.....62763	1151.....64356	1064.....66013	8
	1430.....59775	1333.....61254	1240.....62789	1150.....64383	1063.....66041	
23	1429.....59800	1332.....61279	1238.....62815	1148.....64410	1061.....66069	7
	1427.....59824	1330.....61304	1237.....62841	1147.....64437	1060.....66098	
24	1425.....59848	1329.....61330	1235.....62867	1145.....64464	1059.....66126	6
	1424.....59873	1327.....61355	1234.....62893	1144.....64491	1057.....66154	

DEGREES/MINUTES	COL-1 (ADD)	COL-2 (SUBTRACT)	COL-3 (ADD)	COL-4 (SUBTRACT)
T: <u>71° 31'</u>	A: <u>2300</u>			
L: <u>51° 32'</u>	B: <u>20617</u>	A: <u>10625</u>		
	A: <u>22917</u>	B: <u>9292</u>	B: _____	A: _____
K: <u>75° 52' 30"</u>		A: <u>1333</u>		
L: _____				

Figure 9-33. Determining K value.

STEP 9. Record the first COL-3 B value as 9292 (Figure 9-34 ①). It is a repeat of the COL-2 B value.

STEP 10. Enter the value for LAT, or 42 degrees 33 minutes, under the DEGREES/MINUTES column in the appropriate space (Figure 9-34 ②).

STEP 11. Determine the value for KL by subtracting LAT, 42 degrees 33 minutes, from the K value of 75 degrees 52 minutes 30 seconds. The remainder is 33 degrees 19 minutes 30 seconds (Figure 9-34 ③).

K: 75 degrees 52 minutes 30 seconds
 L: - 42 degrees 33 minutes
 KL = 33 degrees 19 minutes 30 seconds

DEGREES/MINUTES	COL-1 (ADD)	COL-2 (SUBTRACT)	COL-3 (ADD)	COL-4 (SUBTRACT)
T: <u>71° 31'</u>	A: <u>2300</u>			
L: <u>51° 32'</u>	B: <u>20617</u>	A: <u>10625</u>		
	A: <u>22917</u>	B: <u>9292</u>	B: <u>9292</u> ①	A: _____
K: <u>75° 52' 30"</u>		A: <u>1333</u>		
L: <u>42° 33'</u> ②				
KL: <u>33° 19' 30"</u> ③				
D ARC: _____			B: _____	A: _____
60 X DEGREES _____			B: _____	A: _____
+ MINUTES + _____				<B _____
TOTAL _____				
TRUE AZIMUTH _____				

Figure 9-34. Work sheet entries.

STEP 12. Locate the KL value, 33 degrees 19 minutes 30 seconds, in the table. The corresponding B value is 7802 (Figure 9-35).

	32°30'		33°00'		33°30'		34°00'		34°30'		
	A	B	A	B	A	B	A	B	A	B	
0	26978.....7397		26389.....7641		25811.....7889		25244.....8143		24687.....8401		30
1	26968.....7401		26379.....7645		25801.....7893		25235.....8147		24678.....8405		29
	26958.....7405		26370.....7649		25792.....7898		25225.....8151		24669.....8409		
	26949.....7409		26360.....7653		25782.....7902		25216.....8155		24660.....8414		
2	26939.....7413		26350.....7657		25773.....7906		25206.....8160		24650.....8418		28
3	26929.....7417		26340.....7661		25763.....7910		25197.....8164		24641.....8422		27
	26919.....7421		26331.....7665		25754.....7914		25188.....8168		24632.....8427		
	26909.....7425		26321.....7670		25744.....7919		25178.....8172		24623.....8431		
4	26899.....7429		26311.....7674		25735.....7923		25169.....8177		24614.....8435		26
5	26889.....7433		26302.....7678		25725.....7927		25160.....8181		24605.....8440		25
	26879.....7437		26292.....7682		25716.....7931		25150.....8185		24595.....8444		
	26869.....7441		26282.....7686		25706.....7935		25141.....8189		24586.....8448		
6	26860.....7445		26273.....7690		25697.....7940		25132.....8194		24577.....8453		24
7	26850.....7449		26263.....7694		25687.....7944		25122.....8198		24568.....8457		
	26840.....7453		26253.....7698		25678.....7948		25113.....8202		24559.....8461		
							25103.....8207		24550.....8465		
18											
19	26604.....7551		26022.....7798		25451.....8045		24890.....8305		24349.....8567		
	26594.....7555		26012.....7802		25441.....8053		24881.....8310		24331.....8571		
20	26584.....7559		26002.....7806		25432.....8058		24872.....8314		24322.....8575		10
21	26574.....7563		25993.....7810		25422.....8062		24862.....8318		24313.....8580		9
	26565.....7567		25983.....7814		25413.....8066		24853.....8323		24304.....8584		
	26555.....7571		25974.....7818		25403.....8070		24844.....8327		24295.....8589		
22	26545.....7575		25964.....7823		25394.....8075		24835.....8331		24286.....8593		8
23	26535.....7579		25954.....7827		25385.....8079		24826.....8336		24276.....8597		7
	26526.....7584		25945.....7831		25375.....8083		24817.....8340		24267.....8602		
	26516.....7588		25935.....7835		25366.....8087		24808.....8345		24258.....8606		
24	26506.....7592		25926.....7839		25356.....8091				24249.....8611		6
25	26496.....7596		25916.....7843		25347.....8096				24240.....8615		5
	26486.....7600		25907.....7848		25338.....8100				24231.....8619		
	26477.....7604		25897.....7852		25328.....8104				24222.....8624		
26	26467.....7608		25887.....7856		25319.....8108				24213.....8628		4
27	26457.....7612		25878.....7860		25309.....8113				24204.....8633		3
	26447.....7616		25868.....7864		25300.....8117				24195.....8637		
	26438.....7620		25859.....7868		25291.....8121				24186.....8641		
28	26428.....7625		25849.....7873		25281.....8125				24177.....8646		2
29	26418.....7629		25840.....7877		25272.....8130				24168.....8650		1
	26409.....7633		25830.....7881		25263.....8134				24159.....8655		

Figure 9-35. B value for 33 degrees 19 minutes 30 seconds.

STEP 13. Add the COL-3 B values. The sum and final B value is 17094 (Figure 9-36 ①).

B: 9292
B: + 7802
B = 17094

STEP 14. Record the first COL-4 A value as 22917 (Figure 9-36 ②). It is a repeat of the final COL-1 A value.

FROM: Needham's Villa TO: London, England

LAT: 42° 33' North LAT: 51° 32' North

LONG: 71° 36' West LONG: 00° 05' West

T is determined by the following conditions; If long and long' are the same name SUBTRACT. If long and long' are different names ADD.

T 71° 31'

DEGREES/MINUTES	COL -1 (ADD)	COL -2 (SUBTRACT)	COL -3 (ADD)	COL -4 (SUBTRACT)
T: <u>71° 31'</u>	A: <u>2300</u>			
L': <u>51° 32'</u>	B: <u>20617</u>	A: <u>10625</u>		
	A: <u>22917</u>	B: <u>9292</u>	B: <u>9292</u>	A: <u>22917</u> ②
K: <u>75° 52' 30"</u>		A: <u>1333</u>		
L: <u>42° 33'</u>				
KL: <u>33° 19' 30"</u>				
D ARC: _____				
60 X DEGREES _____				A: _____
+ MINUTES _____				<B _____
TOTAL _____				
TRUE AZIMUTH _____				

① B: 7802

B: 17094 A: _____

If other logarithm tables are used instead of dead-reckoning altitude and azimuth tables, column A equates to log cosecant, and column B equates to log secant.

Figure 9-36. GCAD work sheet entries.

STEP 15. Locate the COL-3 final B value, 17094, in the table (Figure 9-37 (1)). The corresponding COL-4 A value is 13185.

A: 22917

A: - 13185

A = 9732

STEP 16. Subtract the COL-4 A value, 13185 (Figure 9-37 (2)), from the 22917. The final COL-4 value is 9732 (Figure 9-37 (3)).

	47°30'	48°00'	48°30'	49°00'	49°30'	
	A B	A B	B	A B		
0	13237.....17032	12893.....17449	1222.....18306	11895.....18746		30
	13231.....17039	12887.....17456	12216.....18313	11890.....18753		
1	13225.....17045	12881.....17463	12211.....18320	11885.....18760		29
	13220.....17052	12876.....17470	12205.....18327	11879.....18768		
2	13214.....17059	12870.....17477	12200.....18335	11874.....18775		28
	13208.....17066	12864.....17484	12195.....18342	11868.....18783		
3	13202.....17073	12858.....17491	12189.....18349	11863.....18790		27
	13196.....17080	12852.....17498	12184.....18357	11858.....18797		
4	13191.....17087	12847.....17505	12178.....18364	11852.....18805		26
	13185.....17094	12841.....17512	12173.....18371	11847.....18812		
5	13179.....17101	12836.....17519	12167.....18378	11842.....18820		25
	13173.....17108	12830.....17526	12162.....18386	11836.....18827		
6	13168.....17114	12824.....17533	12156.....18393	11831.....18834		24
	13162.....17121	12819.....17540	12151.....18400	11825.....18842		
7	13156.....17128	12813.....17547	12145.....18408	11820.....18849		23
	13150.....17135	12807.....17554	12140.....18415	11815.....18857		
8	13144.....17142	12802.....17561	12134.....18423	11809.....18864		22
	13139.....17149	12796.....17568	12129.....18430	11804.....18872		
9	13133.....17156	12791.....17575	12123.....18438	11799.....18879		21
	13127.....17163	12785.....17582	12118.....18445	11793.....18886		
10	13121.....17170	12780.....17589	12112.....18453	11788.....18894		20
	13116.....17177	12774.....17596	12107.....18460	11782.....18901		
11	13110.....17184	12769.....17603	12101.....18468	11777.....18909		19
	13104.....17191	12763.....17610	12096.....18475	11772.....18916		
12	13098.....17198	12758.....17617	12090.....18483	11766.....18924		18
	13093.....17205	12752.....17624	12085.....18490	11761.....18931		
13	13087.....17212	12747.....17631	12079.....18498	11756.....18939		17
	13081.....17219	12741.....17638	12074.....18505	11750.....18946		
14	13075.....17226	12736.....17645	12068.....18513	11745.....18953		16
	13070.....17233	12730.....17652	12063.....18520	11740.....18961		
15	13064.....17240	12725.....17659	12057.....18528	11734.....18968		15
	13058.....17247	12719.....17666	12052.....18535	11729.....18976		
16	13053.....17254	12714.....17673	12046.....18543	11724.....18983		14
	13047.....17261	12708.....17680	12041.....18550	11718.....18991		
17	13041.....17268	12703.....17687	12035.....18558	11713.....18998		13
	13035.....17275	12697.....17694	12030.....18565	11708.....19006		
18	13030.....17282	12692.....17701	12024.....18573	11702.....19013		12
	13024.....17289	12686.....17708	12019.....18580	11697.....19021		
19	13018.....17296	12681.....17715	12013.....18588	11692.....19028		11
	13012.....17303	12675.....17722	12008.....18595	11686.....19036		
20	13007.....17310	12666.....17731	12002.....18603	11681.....19043		10
	13001.....17316	12661.....17738	12327.....18168	11998.....18605		

B: 9292 A: 22917

B: 7802
17094 A: 13185 (2)

A: (3) 9732

<B _____

Figure 9-37. Determining COL-4 entries.

STEP 17. Locate the COL-4 final A value, 9732, in the table (Figure 9-38). Again refer to rule 1 and determine if $\angle B$ is taken from the top or the bottom of the table. Since K is greater than L, $\angle B$ is selected from the top of the table. Therefore, $\angle B$ or the true azimuth from

Needham's Villa to London, England, is 53 degrees 03 minutes 30 seconds. Refer to rule 3 and determine if $\angle B$ is the true bearing. The initial position is west of the final position. Therefore, 53 degrees 03 minutes 30 seconds is the true azimuth.

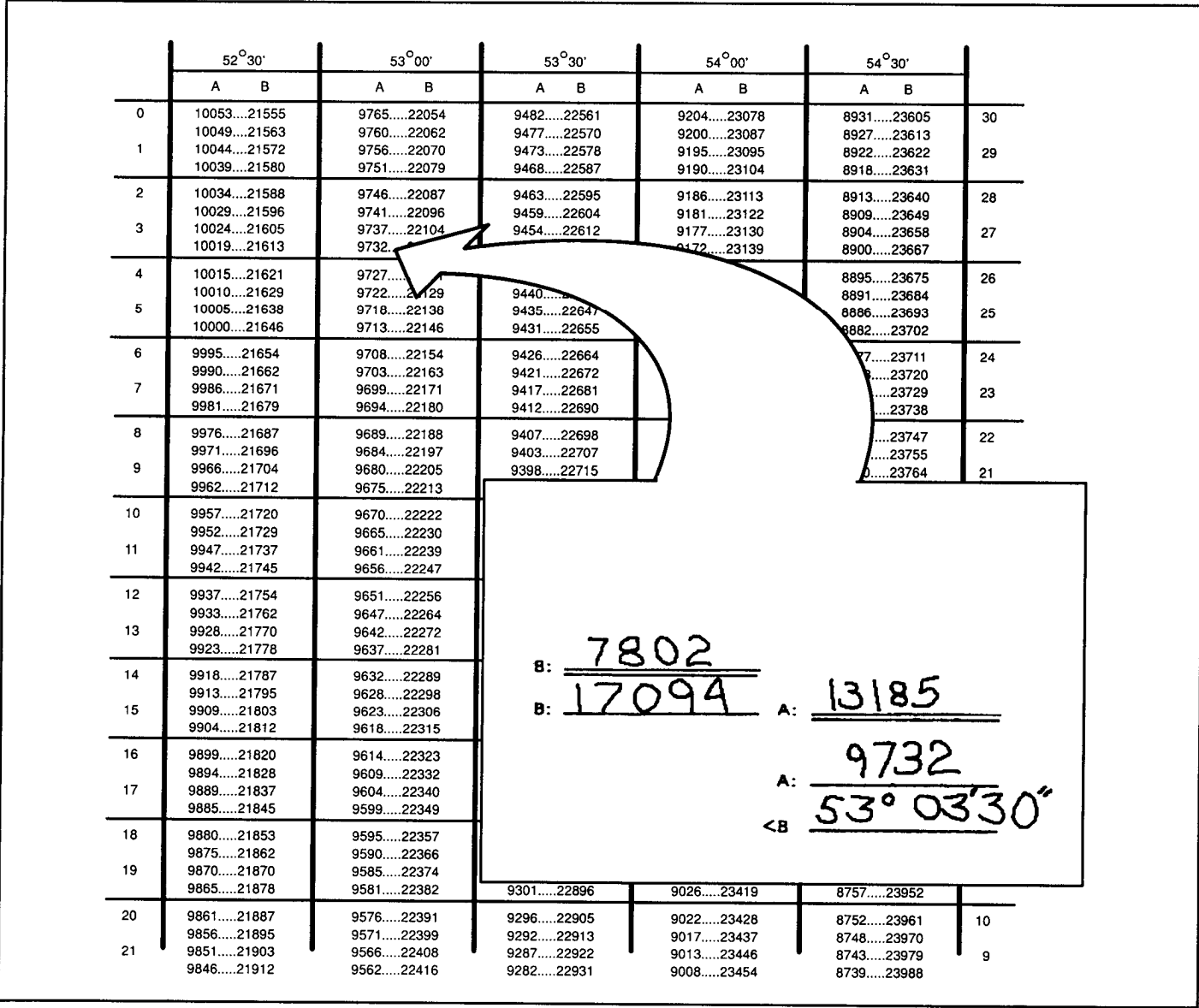


Figure 9-38. Determining $\angle B$.

STEP 18. To determine D arc, locate the final COL-3 B value, 17094, in the table (Figure 9-39 ①). Refer to rule 1 to determine if D arc is taken from the top or the bottom of the table. Since T and KL are both less than 90 degrees, D arc is taken from the top of the table. It is 47 degrees 34 minutes 30 seconds (Figure 9-39 ②).

STEP 19. To compute the distance from the initial to the final position in nautical miles, multiply D arc by 60. To obtain statute miles, multiply the total nautical miles by 1.15.

D arc = 47 degrees 34 minutes 30 seconds

$$47 \times 60 = 2820 \quad (\text{Figure 9-39 } ③)$$

$$+ 34.5 \quad (\text{Figure 9-39 } ④)$$

$$\text{Total nautical miles} = 2854.5 \quad (\text{Figure 9-39 } ⑤)$$

$$\times 1.15$$

$$142725$$

$$28545$$

$$\underline{28545}$$

$$\text{Total statute miles} = 3282.675$$

	47°30'	48°00'	48°30'	49°00'	49°30'	
	A B	A B	A B	A B	A B	
0	13237....17032	12893....17449	12554....17873	12222....18306	11895....18746	30
	13231....17039	12887....17456	12549....17881	12216....18313	11890....18753	
1	13225....17045	12881....17463	12543....17888	12211....18320	11885....18760	29
	13220....17052	12876....17470	12538....17895	12205....18327	11879....18768	
2	13214....17059	12870....17477	12532....17902	12200....18335	11874....18775	28
	13208....17066	12864....17484	12526....17909	12195....18342	11868....18783	
3	13202....17073	12859....17491	12521....17916	12189....18349	11863....18790	27
	13196....17080	12853....17498	12515....17924	12184....18357	11858....18797	
4	13191....17087	12847....17505	12510....17931	12178....18364	11852....18805	26
	13185....17094	12841....17512	12504....17938	12173....18371	11847....18812	
5	13179....17101	12835....17519	12499....17945	12167....18378	11842....18820	25
	13173....17108	12830....17526	12493....17952	12162....18386	11836....18827	
6	13168....17114	12824....17533	12488....17959	12156....18393	11831....18834	24
	13162....17121	12819....17540	12482....17966	12151....18400	11825....18842	
7	13156....17128	12813....17547	12477....17973	12145....18408	11820....18849	23
	13150....17135	12807....17554	12471....17980	12140....18415	11815....18857	
8	13144....17142	12802....17561	12465....17987	12134....18423	11809....18864	22
	13139....17149	12796....17568	12460....17994	12129....18430	11804....18872	
9	13133....17156	12790....17576	12454....17999	12123....18438	11799....18879	21
	13127....17163	12785....17583	12448....18006	12118....18445	11793....18886	
10	13121....17170	12779....17590	12442....18013	12112....18453	11788....18894	20
	13116....17177					
11	13110....17184					
	13104....17191					
12	13098....17198					
	13093....17205					
13	13087....17212					
	13081....17218					
14	13075....17225					

K: 75°52'30"
L: 42°33'

KL: 33°19'30"
D ARC: 47°34'30"

②
③ 60 X DEGREES 2820

④ + MINUTES 34.5

⑤ TOTAL 2854.5 NAUTICAL MILES; 3282.675 STATUTE MILES
TRUE AZIMUTH 53°03'30"

Figure 9-39. Determining D arc and total distance.

STATISTICAL FACTORS

Statistical analysis is an invaluable management tool for measuring direction finding performance. An estimate of the amount of error found in individual bearings is provided through the proper application of statistics. The probable amount of error of the DF site or even the complete DF net can also be determined. Normally, plotting and evaluation centers are responsible for performing accuracy studies. However, direction finding supervisors and analysts must be knowledgeable of statistical analysis procedures. They must be able to compute the analytical computations outlined in this section.

Systematic Error

Systematic error represents the difference between the true bearing and the mean bearing of a transmitter. The true bearing is determined by computing a great circle azimuth from the DF site to the selected target station. The average bearing is determined by taking a large number of bearings on the selected transmitter—a minimum of 200—and computing the average or mean bearing of the sample.

The following criteria is considered when selecting a check station:

- The frequency should be compatible with operational targets.
- The location should be within the area of interest or within a very close proximity.
- The distance should not be significantly different from that of operational targets.

The following definitions are used:

- Bearing mean (BM) is the mean bearing between the DF site and the selected check station.
- Bearing true (BT) is the true bearing between the DF site and the selected check station.

NOTE: Systematic error is computed using the formula:

$$SE = BM \text{ minus } BT$$

The following steps outline the procedure for computing the systematic error:

STEP 1. Visually inspect the reported bearings.

Eliminate the wild bearings. (A wild bearing is considered plus or minus 8 degrees from the true bearing.)

STEP 2. Mathematically compute the mean bearing from the remaining bearings.

STEP 3. Determine the difference between the mean and true bearings. The difference is the systematic error.

NOTE: Systematic error must always be expressed as a negative or positive error. If the mean bearing is smaller than the true bearing, the error is negative. However if the mean bearing is larger than the true bearing, the error is positive.

The following example illustrates the computation of systematic error using the formula $SE = BM - BT$. The true azimuth of the check station is 029 degrees. The following bearings were observed on the selected check station: 028, 034, 013, 023, 029, 036, 058, 029, 032, 035, 033, 038, 021, 028, 031, 027, and 031 degrees.

NOTE: In practical applications, at least 200 bearings must be obtained on the selected check station.

STEP 1. Inspect all reported bearings to ensure there are no wild bearings. In this example, 013, 038, and 058 degrees are wild; they are removed from our computation.

STEP 2. Compute the mean bearing.

028°	033°
034°	0210
023°	028°
029°	031°
036°	027°
029°	<u>031°</u>
032°	417° divided by 14 = 29.7857 degrees
035°	

STEP 3. Determine the difference between the mean and true bearings. The difference is the systematic error.

$$SE = BM - BT$$

$$SE = 029.79 - 029.0 \text{ degrees}$$

$$SE = +0.79 \text{ degrees}$$

Variance

Variance is used as a reliability factor and indicates the quality of bearings used in the computation of the mean bearing. Variance provides the measure of spread or the dispersion of bearings around the mean bearing. The analysis of either site or individual operator variance on selected check stations provides the supervisor with an additional management tool for evaluating efficiency. The formula for computing variance is:

- σ^2 is the symbol for variance.
- $\sum$ indicates the algebraic sum.
- $(BM - BO)^2$ is the bearing observed (BO) subtracted from the mean bearing. The difference or remainder is then squared.
- N is the total number of bearings within plus or minus 8 degrees of the mean bearing.

The following steps outline the procedure for computing variance:

STEP 1. Visually inspect all reported bearings and eliminate the obvious wild bearings.

STEP 2. Mathematically compute the mean bearing from the remaining bearings.

STEP 3. Eliminate any of the remaining bearings which deviate more than plus or minus 8 degrees from the computed mean bearing.

STEP 4. Recompute the mean bearing, if necessary.

STEP 5. Determine the deviation of each observed bearing from the mean bearing. Square each deviation.

STEP 6. Add the squared deviations. Divide the sum by the total number of bearings used. The result is the variance.

NOTE: Due to the squaring process in step 5, the negative sign no longer applies.

For example, the following bearings were observed on a selected check station: 330, 326, 333, 334, 325, 331, 330, 329, 328, and 334 degrees.

NOTE: In practical applications, at least 200 bearings must be obtained on the selected check station.

STEP 1. A visual inspection proves there are no obvious wild bearings.

STEP 2. Compute the mean bearing.

STEPS 3 and 4. Since there are no bearings which deviate over plus or minus 8 degrees from the computed mean, proceed to step 5.

STEP 5. Determine the deviation of each observed bearing from the mean bearing. Square each deviation.

BM	BO	Remainder	Squared
330°	– 330°	0° =	0
330°	– 326°	4° =	16
330°	– 333°	–3° =	9
330°	– 334°	–4° =	16
330°	– 325°	–5° =	25
330°	– 331°	–1° =	1
330°	– 330°	0° =	0
330°	– 329°	1° =	1
330°	– 328°	2° =	4
330°	– 334°	–4° =	16

STEP 6. Add the squared deviations and divide by the number of bearings used. The result is the variance.

$$\begin{array}{r} 0 \\ 16 \\ 9 \\ 16 \\ 25 \\ 1 \\ 0 \\ 1 \\ 4 \\ \underline{16} \end{array}$$

$$\overline{88} \div 10 = 8.8$$

The variance is 8.8

Square Root

Although standard deviation is another direction finding statistical factor, before it can be addressed, it is necessary to be able to manually compute square root. Pocket calculators and other machine aids can perform this function much faster. However, the need for manual computation of square root may arise. The following steps outline the procedure for obtaining the square root of the number 3.4:

STEP 1. Starting at the decimal point, mark off the digits in pairs in both directions. Add zeros, as necessary.

$\sqrt{03.40\ 00}$

STEP 2. Place the decimal point for the answer directly above the decimal point that appears under the radical sign.

$$\sqrt{} \begin{array}{r} \\ 03.40 \ 00 \end{array}$$

STEP 3. Determine by inspection the largest number that can be squared without exceeding the first pair of digits-03. The answer is 1. This is because the square of any number larger than 1 will be greater than 03, Place the 1 above the first pair of digits.

1.
 $\sqrt{03.40\ 00}$

STEP 4. Multiply 1 by itself. This equals 1. Place the 1 under the 03. Subtract 1 from 03. This equals 2. Then bring down the next pair of digits.

1. $\sqrt{03.40\ 00}$
1
 2 40

STEP 5. Double the answer or quotient of 1 (1 doubled equals 2). Place the 2 to the immediate left of 240. Determine the number that can be multiplied by 2 and that same number, but do not exceed 240. The answer is 8 since $28 \times 8 = 224$. (The number 9 would prove to be too large since $29 \times 9 = 261$.) Place the number 8 to the right of the decimal in the quotient. Subtract the 224 from 240 and bring down the next pair of numbers-00.

$$\begin{array}{r} 1.\boxed{8} \\ \sqrt{03.40\ 00} \\ \underline{1} \\ 2\ \boxed{8} \\ \underline{2\ 24} \\ 16\ 00 \end{array}$$

STEP 6. Disregarding the decimal point, double the quotient 18, obtaining 36. Place the 36 to the left of the 1600. Determine the number that can be multiplied by 36 and that same number, but do not exceed 1600. The answer is 4 as $36 \times 4 = 1456$. (The number 5 would be too large since $36 \times 5 = 1825$.) Place the 4 above the second pair of digits.

$$\begin{array}{r}
 1.8 \boxed{4} \\
 \sqrt{03.40\ 00} \\
 \underline{1} \\
 28\ 2\ 40 \\
 \underline{2\ 24} \\
 36 \boxed{4}\ 16\ 00 \\
 \underline{14\ 56} \\
 1\ 44
 \end{array}$$

Depending on the degree of accuracy desired, you can continue the process indefinitely by adding zeros. For direction finding purposes, two places to the right of the decimal are sufficient. The square root of 3.40 is 1.84 or $1.84^2 = 3.3856$.

Standard Deviation

Standard deviation is perhaps the best statistical method of evaluating direction finding site performance. Systematic error is indicative of average error. Standard deviation is a representative of site reliability. Standard deviation is a probability figure which indicates the spread of bearings on one or more targets. In this respect, the smaller the number or SD, the greater the reliability that is attributed to the direction finding site. Standard deviation is computed using the formula:

- BT is the true bearing between the DF site and the selected check station.
- BO is the observed bearing of the selected check station,
- N is the total number of bearings, within plus or minus 8 degrees of the mean bearing, used in the computation.
- $(SE)^2$ is the systematic error squared.

The following steps outline the procedure for computing the standard deviation:

STEP 1. Compute the SE of a selected check station using a minimum of 200 bearings.

STEP 2. For each observed bearing, determine the deviation in degrees from the true bearings. (If the true bearing on the selected check station is not known, a great circle azimuth must be computed.)

STEP 3. Square each deviation.

STEP 4. Add the squared deviations. Divide the sum by the total number of bearings used in the computation, within plus or minus 8 degrees of the mean bearing. This step satisfies the $\frac{(BT-BO)^2}{N}$ portion of the formula.

STEP 5. Square the SE obtained in step 1. Subtract the $(SE)^2$ from the number obtained in step 4.

STEP 6. Compute the square root of the number obtained in step 5. The square root represents the standard deviation of the direction finding site.

The following example illustrates the computation of standard deviation. To prevent a lengthy illustration, only 10 bearings are used. The following information is provided:

SE = -001 degree

BT = 031 degrees

The following bearings were observed on the selected check station: 029, 025, 032, 029, 034, 032, 030, 028, 034, and 027 degrees.

STEP 1. An SE of -001 degree is provided.

STEP 2. Subtract the BO from the BT.

BT	BO	Remainder
0310	– 029°	= 2°
0310	– 025°	= 6°
031°	– 032°	= –1°
031°	– 029°	= 2°
0310	– 034°	= –3°
031°	– 032°	= –10
0310	– 030°	= 1°
031°	– 028°	= 3°
031°	– 034°	= –3°
031°	– 027°	= 4°

STEP 3. Square the remainder obtained in step 2.

Remainder	Squared
2°	4
6°	36
–10	1
2°	4
–3°	9
–10	1
1°	1
3°	9
–3°	9
4°	16

STEP 4. Add the squared deviations and divide by the total number of bearings used in the computation.

4
36
1
4
9
1
1
9
9
16
90÷10=9

This step satisfies $\frac{(BT-BO)^2}{N}$ portion of the formula.

STEP 5. Square the SE and subtract the result from the number obtained in step 4.

$$\begin{aligned} &\sqrt{9-(SE)^2} \\ &\sqrt{9-(-001)^2} \\ &\sqrt{9-1} \\ &\sqrt{8} \end{aligned}$$

STEP 6. Compute the square root.

$$\begin{array}{r} \sqrt{8} \\ \hline 2. \quad 8 \quad 2 \\ \hline 08. \quad 00 \quad 00 \\ \underline{4} \\ 48 \quad 4 \quad 00 \\ \underline{3 \quad 84} \\ 562 \quad 16 \quad 00 \\ \underline{11 \quad 24} \\ 4 \quad 76 \end{array}$$

The standard deviation is 2.82

Standard Deviation/Distance Curve

It is difficult to visualize the effect that distance has on bearings without periodically computing a SD/ distance curve for each DF site within the net (Figure 9-40). The SD/ distance curve for the SSL varies from those of conventional DF systems because the SSL has a better ability to discriminate against the effects of multipath propagation (Figure 9-4 1). Therefore, at distances beyond 1,000 km (below 10 MHz) and 100 Nm (above 10 MHz), the curve for the SSL continues in a straight line and has no further deviation. The primary reason for the SD/ distance curve is to show accurate SD information at the various ranges from each DF site.

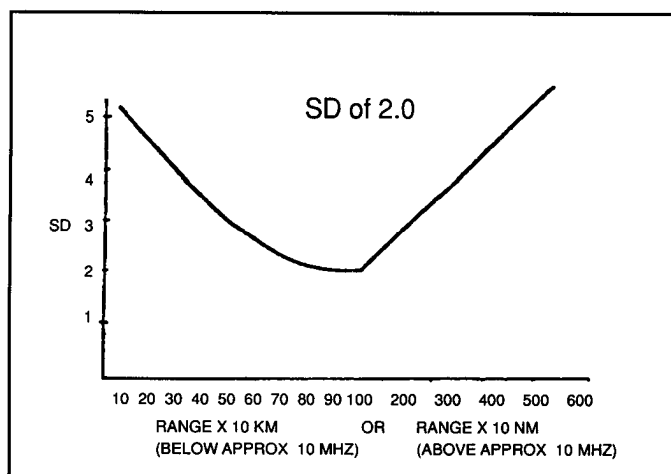


Figure 9-40. SD/distance curve for conventional DF systems.

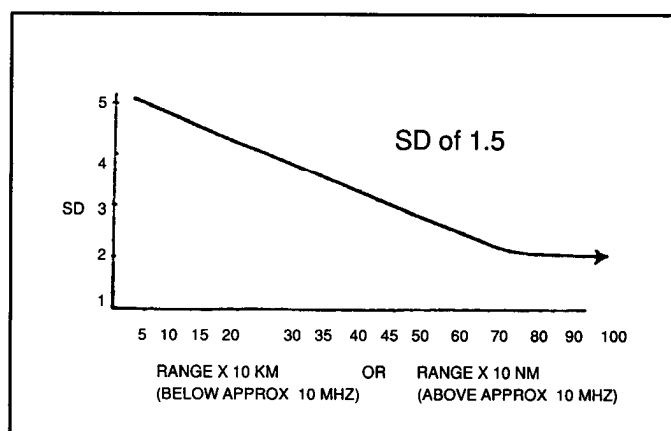


Figure 9-41. SD/distance curve for SSL.

The following formulas are variations taken from the FFIIX computer algorithm and should be used to compute SD/distance tables for each site.

For frequencies less than approximately 10 MHz:

$$\text{SD } (.285714 + .714256 R) = \text{range weighted SD}$$

where R is greater than or equal to 10.

$$\text{SD } (3 - .402R + .204 R^2) = \text{range weighted SD}$$

where R is less than 10.

R is distance in 100 km units.

For frequencies above approximately 10 MHz, use the same formulas and change R to be the distance in 100 Nm units.

Standard Deviation Probability Graph

As stated previously, the statistical measure of SD is dependant on the number and quality of bearings used in the formula (expressed as BM and N). The standard deviation probability graph (Figure 9-42, page 9-38) can be used to calculate the probable accuracy of any data set where the number of bearings (samples) are 1,000 or less. This chart is useful in determining how close an estimated SD will be to the true SD of the site. The vertical axis of the graph represents the total number of samples used to compute the mean bearing (BM). The horizontal axis represents the percentage of accuracy of the BM from the true bearing (BT). The diagonal line represents the percentage of time that the BM will be within the percentage of accuracy which is required.

For example, assume you are working at a site which requires the BM to be accurate to within plus or minus 10 percent of the BT, 80 percent of the time. Locate the accuracy requirement of 10 percent on the bottom horizontal line of the graph. Follow that line upward until it intersects with the diagonal line ($Y = .80$). This indicates the percentage of time. Now look to the left along the vertical line of the graph and you will see that for such accuracy requirements, a minimum of 90 bearings (samples) must be used in the computation of the BM.

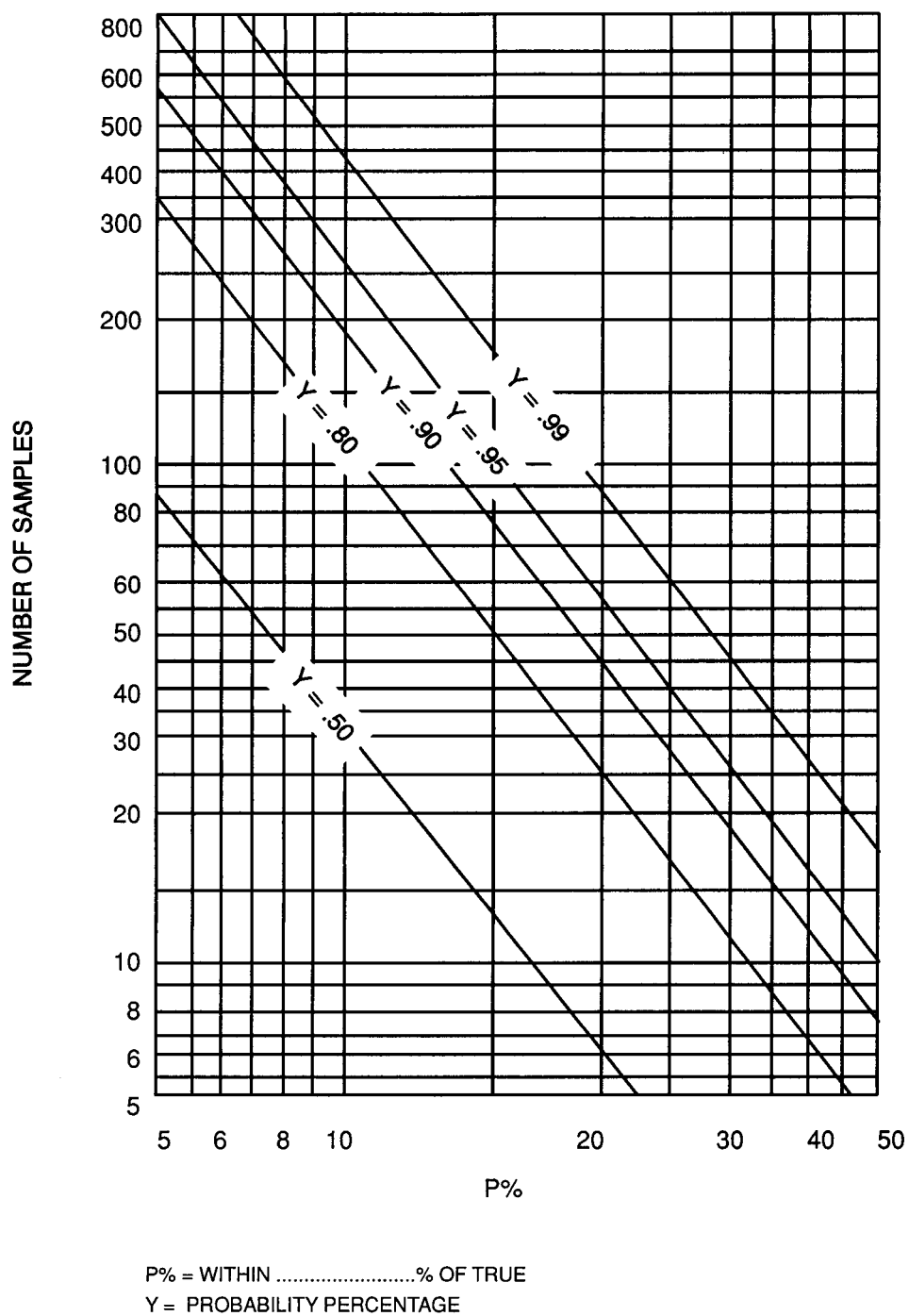


Figure 9-42. SD probability graph.

APPENDIX A

**COMMON LOGARITHMS OF
FUNCTIONS OF ANGLES
IN DEGREES AND
MINUTES
TABLE**

0°..180°		L SIN	D	L TAN	CD	L COT	L COS		
90°..270°		L COS		L COT		L TAN	L SIN		
	0	—		—		—	0.00 000	60	
	1	6.46 373	30103 17609 12494 9691	6.46 373	30103 17609 12494 9691	3.53 627	0.00 000	59	
	2	6.76 476		6.76 476		3.23 524	0.00 000	58	
	3	6.94 085		6.94 085		3.05 915	0.00 000	57	
	4	7.06 579		7.06 579		2.93 421	0.00 000	56	
	5	7.16 270	7918 6694 5800 5115 4576	7.16 270	7918 6694 5800 5115 4576	2.83 730	0.00 000	55	
	6	7.24 188		7.24 188		2.75 812	0.00 000	54	
	7	7.30 882		7.30 882		2.69 118	0.00 000	53	
	8	7.36 682		7.36 682		2.63 318	0.00 000	52	
	9	7.41 797		7.41 797		2.58 203	0.00 000	51	
	10	7.46 373	4139 3779 3476 3218 2997	7.46 373	4139 3779 3476 3219 2996	2.53 627	0.00 000	50	
	11	7.50 512		7.50 512		2.49 488	0.00 000	49	
	12	7.54 291		7.54 291		2.45 709	0.00 000	48	
	13	7.57 767		7.57 767		2.42 233	0.00 000	47	
	14	7.60 985		7.60 986		2.39 014	0.00 000	46	
	15	7.63 982	2802 2633 2483 2348 2227	7.63 982	2803 2633 2482 2348 2228	2.36 018	0.00 000	45	
	16	7.66 784		7.66 785		2.33 215	0.00 000	44	
	17	7.69 417		7.69 418		2.30 582	9.99 999	43	
	18	7.71 900		7.71 900		2.28 100	9.99 999	42	
	19	7.74 248		7.74 248		2.25 752	9.99 999	41	
	20	7.76 475	2119 2021 1930 1848 1773	7.76 476	2119 2020 1931 1848 1773	2.23 524	9.99 999	40	
	21	7.78 594		7.78 595		2.21 405	9.99 999	39	
	22	7.80 615		7.80 615		2.19 385	9.99 999	38	
	23	7.82 545		7.82 546		2.17 454	9.99 999	37	
	24	7.84 393		7.84 394		2.15 606	9.99 999	36	
	25	7.86 166	1704 1639 1579 1524 1472	7.86 167	1704 1639 1579 1524 1473	2.13 833	9.99 999	35	
	26	7.87 870		7.87 871		2.12 129	9.99 999	34	
	27	7.89 509		7.89 510		2.10 490	9.99 999	33	
	28	7.91 088		7.91 089		2.08 911	9.99 999	32	
	29	7.92 612		7.92 613		2.07 387	9.99 998	31	
	30	7.94 084	1424 1379 1336 1297 1259	7.94 086	1424 1379 1336 1297 1259	2.05 914	9.99 998	30	
	31	7.95 508		7.95 510		2.04 490	9.99 998	29	
	32	7.96 887		7.96 889		2.03 111	9.99 998	28	
	33	7.98 223		7.98 225		2.01 775	9.99 998	27	
	34	7.99 520		7.99 522		2.00 478	9.99 998	26	
	35	8.00 779	1223 1190 1158 1128 1100	8.00 781	1223 1190 1159 1128 1100	1.99 219	9.99 998	25	
	36	8.02 002		8.02 004		1.97 996	9.99 998	24	
	37	8.03 192		8.03 194		1.96 806	9.99 997	23	
	38	8.04 350		8.04 353		1.95 647	9.99 997	22	
	39	8.05 478		8.05 481		1.94 519	9.99 997	21	
	40	8.06 578	1072 1046 1022 999 976	8.06 581	1072 1047 1022 998 976	1.93 419	9.99 997	20	
	41	8.07 650		8.07 653		1.92 347	9.99 997	19	
	42	8.08 696		8.08 700		1.91 300	9.99 997	18	
	43	8.09 718		8.09 722		1.90 278	9.99 997	17	
	44	8.10 717		8.10 720		1.89 280	9.99 996	16	
	45	8.11 693	954 934 914 896 877	8.11 696	955 934 915 895 878	1.88 304	9.99 996	15	
	46	8.12 647		8.12 651		1.87 349	9.99 996	14	
	47	8.13 581		8.13 585		1.86 415	9.99 996	13	
	48	8.14 495		8.14 500		1.85 500	9.99 996	12	
	49	8.15 391		8.15 395		1.84 605	9.99 996	11	
	50	8.16 268	860 843 827 812 797	8.16 273	860 843 828 812 797	1.83 727	9.99 995	10	
	51	8.17 128		8.17 133		1.82 867	9.99 995	9	
	52	8.17 971		8.17 976		1.82 024	9.99 995	8	
	53	8.18 798		8.18 804		1.81 106	9.99 995	7	
	54	8.19 610		8.19 616		1.80 384	9.99 995	6	
	55	8.20 407	782 769 755 743 730	8.20 413	782 769 756 742 730	1.79 587	9.99 994	5	
	56	8.21 189		8.21 195		1.78 805	9.99 994	4	
	57	8.21 958		8.21 964		1.78 036	9.99 994	3	
	58	8.22 713		8.22 720		1.77 280	9.99 994	2	
	59	8.23 456		8.23 462		1.76 538	9.99 994	1	
	60	8.24 186		8.24 192		1.75 808	9.99 993	0	
		L SIN	D	L TAN	CD	L COT	L COS		359°..179°
		L COS		L COT		L TAN	L SIN		269°...89°

1°...181°		L SIN	D	L TAN	CD	L COT	L COS		
91°...271°		L COS		L COT		L TAN	L SIN		
	0	8.24 186	717	8.24 192	718	1.75 808	9.99 993	60	
	1	8.24 903	706	8.24 910	706	1.75 090	9.99 993	59	
	2	8.25 609	695	8.25 616	696	1.74 384	9.99 993	58	
	3	8.26 304	684	8.26 312	684	1.73 688	9.99 993	57	
	4	8.26 988	673	8.26 996	673	1.73 004	9.99 992	56	
	5	8.27 661	663	8.27 669	663	1.72 331	9.99 992	55	
	6	8.28 324	653	8.28 332	654	1.71 668	9.99 992	54	
	7	8.28 977	644	8.28 986	643	1.71 014	9.99 992	53	
	8	8.29 621	634	8.29 629	634	1.70 371	9.99 992	52	
	9	8.30 255	624	8.30 263	625	1.69 737	9.99 991	51	
	10	8.30 879	616	8.30 888	617	1.69 112	9.99 991	50	
	11	8.31 495	608	8.31 505	607	1.68 495	9.99 991	49	
	12	8.32 103	599	8.32 112	599	1.67 888	9.99 990	48	
	13	8.32 702	590	8.32 711	591	1.67 289	9.99 990	47	
	14	8.33 292	583	8.33 302	584	1.66 698	9.99 990	46	
	15	8.33 875	575	8.33 886	575	1.66 114	9.99 990	45	
	16	8.34 450	568	8.34 461	568	1.65 539	9.99 989	44	
	17	8.35 018	560	8.35 029	561	1.64 971	9.99 989	43	
	18	8.35 578	553	8.35 590	553	1.64 410	9.99 989	42	
	19	8.36 131	547	8.36 143	546	1.63 857	9.99 989	41	
	20	8.36 678	539	8.36 689	540	1.63 311	9.99 988	40	
	21	8.37 217	533	8.37 229	533	1.62 771	9.99 988	39	
	22	8.37 750	526	8.37 762	527	1.62 238	9.99 988	38	
	23	8.38 276	520	8.38 289	520	1.61 711	9.99 987	37	
	24	8.38 796	514	8.38 809	514	1.61 191	9.99 987	36	
	25	8.39 810	506	8.39 823	509	1.60 677	9.99 987	35	
	26	8.39 818	502	8.39 832	502	1.60 168	9.99 986	34	
	27	8.40 320	496	8.40 334	496	1.59 666	9.99 986	33	
	28	8.40 816	491	8.40 830	491	1.59 170	9.99 986	32	
	29	8.41 307	485	8.41 321	486	1.58 679	9.99 985	31	
	30	8.41 792	480	8.41 807	480	1.58 193	9.99 985	30	
	31	8.42 272	474	8.42 287	475	1.57 713	9.99 985	29	
	32	8.42 746	470	8.42 762	470	1.57 238	9.99 984	28	
	33	8.43 216	464	8.43 232	464	1.56 768	9.99 984	27	
	34	8.43 680	459	8.43 696	460	1.56 304	9.99 984	26	
	35	8.44 139	455	8.44 156	455	1.55 844	9.99 983	25	
	36	8.44 594	450	8.44 611	450	1.55 389	9.99 983	24	
	37	8.45 044	445	8.45 061	446	1.54 939	9.99 983	23	
	38	8.45 489	441	8.45 507	441	1.54 493	9.99 982	22	
	39	8.45 930	436	8.45 948	437	1.54 052	9.99 982	21	
	40	8.46 366	433	8.46 385	432	1.53 615	9.99 982	20	
	41	8.46 799	427	8.46 817	428	1.53 183	9.99 981	19	
	42	8.47 226	424	8.47 245	424	1.52 755	9.99 981	18	
	43	8.47 650	419	8.47 669	420	1.52 331	9.99 981	17	
	44	8.48 069	416	8.48 089	416	1.51 911	9.99 980	16	
	45	8.48 485	411	8.48 505	412	1.51 495	9.99 980	15	
	46	8.48 896	408	8.48 917	408	1.51 083	9.99 979	14	
	47	8.49 304	404	8.49 325	404	1.50 675	9.99 979	13	
	48	8.49 708	400	8.49 729	401	1.50 271	9.99 979	12	
	49	8.50 108	396	8.50 130	397	1.49 870	9.99 978	11	
	50	8.50 504	393	8.50 527	393	1.49 473	9.99 978	10	
	51	8.50 897	390	8.50 920	390	1.49 080	9.99 977	9	
	52	8.51 287	386	8.51 310	386	1.48 690	9.99 977	8	
	53	8.51 673	382	8.51 696	383	1.48 304	9.99 977	7	
	54	8.52 055	379	8.52 079	380	1.47 921	9.99 976	6	
	55	8.52 434	376	8.52 459	376	1.47 541	9.99 976	5	
	56	8.52 810		8.52 835	373	1.47 165	9.99 975	4	
	57	8.53 183		8.53 208	370	1.46 792	9.99 975	3	
	58	8.53 552		8.53 578	367	1.46 422	9.99 974	2	
	59	8.53 919		8.53 945	363	1.46 055	9.99 974	1	
60	8.54 282		8.54 308		1.45 692	9.99 974	0		
		L SIN	D	L TAN	CD	L COT	L COS		358°...178°
		L COS		L COT		L TAN	L SIN		268°...88°

2°..182°		L SIN	D	L TAN	CD	L COT	L COS	
92°..272°		L COS		L COT		L TAN	L SIN	
	0	8.54 282	360	8.54 308	361	1.45 692	9.99 974	60
	1	8.54 642	357	8.54 669	358	1.45 331	9.99 973	59
	2	8.54 999	355	8.55 027	355	1.44 973	9.99 973	58
	3	8.55 354	351	8.55 382	352	1.44 618	9.99 972	57
	4	8.55 705	349	8.55 734	349	1.44 266	9.99 972	56
	5	8.56 054		8.56 083	346	1.43 917	9.99 971	55
	6	8.56 400	346	8.56 429	344	1.43 571	9.99 971	54
	7	8.56 743	343	8.56 773	341	1.43 227	9.99 970	53
	8	8.57 084	341	8.57 114	338	1.42 886	9.99 970	52
	9	8.57 421	337	8.57 452	336	1.43 548	9.99 969	51
			336					
	10	8.57 757	332	8.57 788	333	1.42 212	9.99 969	50
	11	8.58 089	330	8.58 121	330	1.41 879	9.99 968	49
	12	8.58 419	330	8.58 451	330	1.41 549	9.99 968	48
	13	8.58 747	328	8.58 779	328	1.41 221	9.99 967	47
	14	8.59 072	325	8.59 105	326	1.40 895	9.99 967	46
			323		323			
	15	8.59 395	320	8.59 428	321	1.40 572	9.99 967	45
	16	8.59 715	318	8.59 749	319	1.40 251	9.99 966	44
	17	8.60 033	316	8.60 068	316	1.39 932	9.99 966	43
	18	8.60 349	313	8.60 384	314	1.39 616	9.99 965	42
	19	8.60 662	311	8.60 698	311	1.39 302	9.99 964	41
	20	8.60 973	309	8.61 009	310	1.38 991	9.99 964	40
	21	8.61 282	307	8.61 319	307	1.38 681	9.99 963	39
	22	8.61 589	305	8.61 626	305	1.38 374	9.99 963	38
	23	8.61 894	302	8.61 931	303	1.38 069	9.99 962	37
	24	8.62 196	301	8.62 234	301	1.37 766	9.99 962	36
	25	8.62 497		8.62 535	299	1.37 465	9.99 961	35
	26	8.62 795	298	8.62 834	297	1.37 166	9.99 961	34
	27	8.63 091	296	8.63 131	295	1.36 869	9.99 960	33
	28	8.63 385	294	8.63 426	292	1.36 574	9.99 960	32
	29	8.63 678	293	8.63 718	291	1.36 282	9.99 959	31
			290					
	30	8.63 963	288	8.64 009	289	1.35 991	9.99 959	30
	31	8.64 256	287	8.64 298	287	1.35 702	9.99 958	29
	32	8.64 543	284	8.64 585	285	1.35 415	9.99 958	28
	33	8.64 827	283	8.64 870	284	1.35 130	9.99 957	27
	34	8.65 110	281	8.65 154	281	1.34 846	9.99 956	26
	35	8.65 391	279	8.65 435	280	1.34 565	9.99 956	25
	36	8.65 670	277	8.65 715	278	1.34 285	9.99 955	24
	37	8.65 947	276	8.65 993	276	1.34 007	9.99 955	23
	38	8.66 223	274	8.66 269	274	1.33 731	9.99 954	22
	39	8.66 497	272	8.66 543	273	1.33 457	9.99 954	21
	40	8.66 789	270	8.66 816	271	1.33 184	9.99 953	20
	41	8.67 039	269	8.67 087	269	1.32 913	9.99 952	19
	42	8.67 308	267	8.67 356	268	1.32 644	9.99 952	18
	43	8.67 575	266	8.67 624	266	1.32 376	9.99 951	17
	44	8.67 841	263	8.67 890	264	1.32 110	9.99 951	16
	45	8.68 104	263	8.68 154	263	1.31 846	9.99 950	15
	46	8.68 367	260	8.68 417	261	1.31 583	9.99 949	14
	47	8.68 627	259	8.68 678	260	1.31 322	9.99 949	13
	48	8.68 886	258	8.68 938	258	1.31 062	9.99 948	12
	49	8.69 144	256	8.69 196	257	1.30 804	9.99 948	11
	50	8.69 400	254	8.69 453	255	1.30 547	9.99 947	10
	51	8.69 654	253	8.69 708	254	1.30 292	9.99 946	9
	52	8.69 907	252	8.69 962	252	1.30 038	9.99 946	8
	53	8.70 159	250	8.70 214	251	1.29 786	9.99 945	7
	54	8.70 409	249	8.70 465	249	1.29 535	9.99 944	6
	55	8.70 658	247	8.70 714	248	1.29 286	9.99 944	5
	56	8.70 905	246	8.70 962	246	1.29 038	9.99 943	4
	57	8.71 151	244	8.71 208	245	1.28 792	9.99 942	3
	58	8.71 395	243	8.71 453	244	1.28 547	9.99 942	2
	59	8.71 638	242	8.71 697	243	1.28 303	9.99 941	1
	60	8.71 880		8.71 940		1.28 060	9.99 940	0
		L SIN	D	L TAN	CD	L COT	L COS	
		L COS		L COT		L TAN	L SIN	
								357°..177°
								267°...87°

3°..183°		L SIN	D	L TAN	CD	L COT	L COS	
93°..273°		L COS		L COT		L TAN	L SIN	
	0	8.71 880		8.71 940		1.28 060	9.99 940	60
	1	8.72 120	240	8.72 181	241	1.27 819	9.99 940	59
	2	8.72 359	239	8.72 420	239	1.27 580	9.99 939	58
	3	8.72 597	239	8.72 659	239	1.27 341	9.99 938	57
	4	8.72 834	237	8.72 896	237	1.27 104	9.99 938	56
			235		236			
	5	8.73 069		8.73 132		1.26 868	9.99 937	55
	6	8.73 303	234	8.73 366	234	1.26 634	9.99 936	54
	7	8.73 535	232	8.73 600	234	1.26 400	9.99 936	53
	8	8.73 767	232	8.73 832	232	1.26 168	9.99 935	52
	9	8.73 997	230	8.74 063	230	1.25 937	9.99 934	51
			229		229			
	10	8.74 226		8.74 292		1.25 708	9.99 934	50
	11	8.74 454	228	8.74 521	229	1.25 479	9.99 933	49
	12	8.74 680	226	8.74 748	227	1.25 252	9.99 932	48
	13	8.74 906	226	8.74 974	226	1.25 026	9.99 932	47
	14	8.75 130	224	8.75 199	225	1.24 801	9.99 931	46
			223		224			
	15	8.75 353		8.75 423		1.24 577	9.99 930	45
	16	8.75 575	222	8.75 645	222	1.24 355	9.99 929	44
	17	8.75 795	220	8.75 867	222	1.24 133	9.99 929	43
	18	8.76 015	220	8.76 087	220	1.23 913	9.99 928	42
	19	8.76 234	219	8.76 306	219	1.23 694	9.99 927	41
			217		219			
	20	8.76 451		8.76 525		1.23 475	9.99 926	40
	21	8.76 667	216	8.76 742	217	1.23 258	9.99 926	39
	22	8.76 883	216	8.76 958	216	1.23 042	9.99 925	38
	23	8.77 097	214	8.77 173	215	1.22 827	9.99 924	37
	24	8.77 610	213	8.77 387	214	1.22 613	9.99 923	36
			212		213			
	25	8.77 522		8.77 600		1.22 400	9.99 923	35
	26	8.77 733	211	8.77 811	211	1.22 189	9.99 922	34
	27	8.77 943	210	8.78 022	211	1.21 978	9.99 921	33
	28	8.78 152	209	8.78 232	210	1.21 768	9.99 920	32
	29	8.78 360	208	8.78 441	209	1.21 559	9.99 920	31
			208		208			
	30	8.78 568		8.78 649		1.21 351	9.99 919	30
	31	8.78 774	206	8.78 855	206	1.21 145	9.99 918	29
	32	8.78 979	205	8.79 061	206	1.20 939	9.99 917	28
	33	8.79 138	204	8.79 266	205	1.20 734	9.99 917	27
	34	8.79 386	203	8.79 470	204	1.20 530	9.99 916	26
			202		203			
	35	8.79 588		8.79 673		1.20 327	9.99 915	25
	36	8.79 789	201	8.79 875	202	1.20 125	9.99 914	24
	37	8.79 990	201	8.80 076	201	1.19 924	9.99 913	23
	38	8.80 189	199	8.80 277	201	1.19 723	9.99 913	22
	39	8.80 388	199	8.80 476	199	1.19 524	9.99 912	21
			197		198			
	40	8.80 585		8.80 674		1.19 326	9.99 911	20
	41	8.80 782	197	8.80 872	198	1.19 128	9.99 910	19
	42	8.80 978	196	8.81 068	196	1.18 932	9.99 909	18
	43	8.81 173	195	8.81 264	196	1.18 736	9.99 909	17
	44	8.81 367	194	8.81 459	195	1.18 541	9.99 908	16
			193		194			
	45	8.81 560		8.81 653		1.18 347	9.99 907	15
	46	8.81 752	192	8.81 846	193	1.18 154	9.99 906	14
	47	8.81 944	192	8.82 038	192	1.17 962	9.99 905	13
	48	8.82 134	190	8.82 230	192	1.17 770	9.99 904	12
	49	8.82 324	190	8.82 420	190	1.17 580	9.99 904	11
			189		190			
	50	8.82 513		8.82 610		1.17 390	9.99 903	10
	51	8.82 701	188	8.82 799	189	1.17 201	9.99 902	9
	52	8.82 888	187	8.82 987	188	1.17 013	9.99 901	8
	53	8.83 075	187	8.83 175	188	1.16 825	9.99 900	7
	54	8.83 261	186	8.83 361	186	1.16 639	9.99 899	6
			185		186			
	55	8.83 446		8.83 547		1.16 453	9.99 898	5
	56	8.83 630	184	8.83 732	185	1.16 268	9.99 898	4
	57	8.83 813	183	8.83 916	184	1.16 084	9.99 897	3
	58	8.83 996	183	8.84 100	184	1.15 900	9.99 896	2
	59	8.84 177	181	8.84 282	182	1.15 718	9.99 895	1
			181		182			
	60	8.84 358		8.84 464		1.15 536	9.99 894	0
		L SIN	D	L TAN	CD	L COT	L COS	
		L COS		L COT		L TAN	L SIN	
								356°..176°
								266°...86°

4° ..184°		L SIN	D	L TAN	CD	L COT	L COS	
94° ..274°		L COS		L COT		L TAN	L SIN	
	0	8.84 358		8.84 464		1.15 536	9.99 894	60
	1	8.84 539	181	8.84 646	182	1.15 354	9.99 893	59
	2	8.84 718	179	8.84 826	180	1.15 174	9.99 892	58
	3	8.84 897	179	8.85 006	180	1.14 994	9.99 891	57
	4	8.85 075	178	8.85 185	179	1.14 815	9.99 891	56
			177		178			
	5	8.85 252		8.85 363		1.14 637	9.99 890	55
	6	8.85 429	177	8.85 540	177	1.14 460	9.99 889	54
	7	8.85 605	176	8.85 717	177	1.14 283	9.99 888	53
	8	8.85 780	175	8.85 893	176	1.14 107	9.99 887	52
	9	8.85 955	175	8.86 069	176	1.13 931	9.99 886	51
			173		174			
	10	8.86 128		8.86 243		1.13 757	9.99 885	50
	11	8.86 301	173	8.86 417	174	1.13 583	9.99 884	49
	12	8.86 474	173	8.86 591	174	1.13 409	9.99 883	48
	13	8.86 645	171	8.86 763	172	1.13 237	9.99 882	47
	14	8.86 816	171	8.86 935	172	1.13 065	9.99 881	46
			171		171			
	15	8.86 987		8.87 106		1.12 894	9.99 880	45
	16	8.87 156	169	8.87 277	171	1.12 723	9.99 879	44
	17	8.87 325	169	8.87 447	170	1.12 553	9.99 879	43
	18	8.87 494	169	8.87 616	169	1.12 384	9.99 878	42
	19	8.87 661	167	8.87 785	169	1.12 215	9.99 877	41
			168		168			
	20	8.87 829		8.87 953		1.12 047	9.99 876	40
	21	8.87 995	166	8.88 120	167	1.11 880	9.99 875	39
	22	8.88 161	166	8.88 287	167	1.11 713	9.99 874	38
	23	8.88 326	165	8.88 453	166	1.11 547	9.99 873	37
	24	8.88 490	164	8.88 618	165	1.11 382	9.99 872	36
			164		165			
	25	8.88 654		8.88 783		1.11 217	9.99 871	35
	26	8.88 817	163	8.88 948	165	1.11 052	9.99 870	34
	27	8.88 980	163	8.89 111	163	1.10 889	9.99 869	33
	28	8.89 142	162	8.89 274	163	1.10 726	9.99 868	32
	29	8.89 304	162	8.89 437	163	1.10 563	9.99 867	31
			160		161			
	30	8.89 464		8.89 598		1.10 402	9.99 866	30
	31	8.89 625	161	8.89 760	162	1.10 240	9.99 865	29
	32	8.89 784	159	8.89 920	160	1.10 080	9.99 864	28
	33	8.89 943	159	8.90 080	160	1.09 920	9.99 863	27
	34	8.90 102	159	8.90 240	160	1.09 760	9.99 862	26
			158		159			
	35	8.90 260		8.90 399		1.09 601	9.99 861	25
	36	8.90 417	157	8.90 557	158	1.09 443	9.99 860	24
	37	8.90 574	157	8.90 715	158	1.09 285	9.99 859	23
	38	8.90 730	156	8.90 872	157	1.09 128	9.99 858	22
	39	8.90 885	155	8.91 029	157	1.08 971	9.99 857	21
			155		156			
	40	8.91 040		8.91 185		1.08 815	9.99 856	20
	41	8.91 195	155	8.91 340	155	1.08 660	9.99 855	19
	42	8.91 349	154	8.91 495	155	1.08 505	9.99 854	18
	43	8.91 502	153	8.91 650	155	1.08 350	9.99 853	17
	44	8.91 655	153	8.91 803	153	1.08 197	9.99 852	16
			152		154			
	45	8.91 807		8.91 957		1.08 043	9.99 851	15
	46	8.91 959	152	8.92 110	153	1.07 890	9.99 850	14
	47	8.92 110	151	8.92 262	152	1.07 738	9.99 848	13
	48	8.92 261	151	8.92 414	152	1.07 586	9.99 847	12
	49	8.92 411	150	8.92 665	151	1.07 435	9.99 846	11
			150		151			
	50	8.92 561		8.92 716		1.07 284	9.99 845	10
	51	8.92 710	149	8.92 866	150	1.07 134	9.99 844	9
	52	8.92 859	149	8.92 016	150	1.06 984	9.99 843	8
	53	8.93 077	148	8.93 165	149	1.06 835	9.99 842	7
	54	8.93 154	147	8.93 313	148	1.06 687	9.99 841	6
			147		149			
	55	8.93 301		8.93 462		1.06 538	9.99 840	5
	56	8.93 448	147	8.93 609	147	1.06 391	9.99 839	4
	57	8.93 594	146	8.93 756	147	1.06 244	9.99 838	3
	58	8.93 740	146	8.93 903	147	1.06 097	9.99 837	2
	59	8.93 885	145	8.94 049	146	1.05 951	9.99 836	1
			145		146			
	60	8.94 030		8.94 195		1.05 805	9.99 834	0
		L SIN	D	L TAN	CD	L COT	L COS	
		L COS		L COT		L TAN	L SIN	
								355° ..175°
								265° ...85°

5° ..185°		L SIN	D	L TAN	CD	L COT	L COS	
95° ..275°		L COS		L COT		L TAN	L SIN	
	0	8.94 030	144	8.94 195	145	1.05 805	9.99 834	60
	1	8.94 174	143	8.94 340	145	1.05 660	9.99 833	59
	2	8.94 317	144	8.94 458	145	1.05 515	9.99 832	58
	3	8.94 461	142	8.94 630	143	1.05 370	9.99 831	57
	4	8.94 603	143	8.94 773	144	1.05 227	9.99 830	56
	5	8.94 746	141	8.94 917	143	1.05 083	9.99 829	55
	6	8.94 887	142	8.95 060	142	1.04 940	9.99 828	54
	7	8.95 029	141	8.95 202	142	1.04 798	9.99 827	53
	8	8.95 170	140	8.95 344	142	1.04 656	9.99 825	52
	9	8.95 310	140	8.95 486	141	1.04 514	9.99 824	51
	10	8.95 450	139	8.95 627	140	1.04 373	9.99 823	50
	11	8.95 589	139	8.95 767	141	1.04 233	9.99 822	49
	12	8.95 728	139	8.95 908	139	1.04 092	9.99 821	48
	13	8.95 867	138	8.96 047	140	1.03 953	9.99 820	47
	14	8.96 005	138	8.96 187	138	1.03 813	9.99 819	46
	15	8.96 143	137	8.96 325	139	1.03 675	9.99 817	45
	16	8.96 280	137	8.96 464	138	1.03 536	9.99 816	44
	17	8.96 417	136	8.96 602	137	1.03 398	9.99 815	43
	18	8.96 553	136	8.96 739	138	1.03 261	9.99 814	42
	19	8.96 689	136	8.96 877	136	1.03 123	9.99 813	41
	20	8.96 825	135	8.97 013	137	1.02 987	9.99 812	40
	21	8.96 960	135	8.97 150	135	1.02 850	9.99 810	39
	22	8.97 095	134	8.97 285	136	1.02 715	9.99 809	38
	23	8.97 229	134	8.97 421	135	1.02 579	9.99 808	37
	24	8.97 363	133	8.97 556	135	1.02 444	9.99 807	36
	25	8.97 496	133	8.97 691	134	1.02 309	9.99 806	35
	26	8.97 629	133	8.97 825	134	1.02 175	9.99 804	34
	27	8.97 762	132	8.97 959	133	1.02 041	9.99 803	33
	28	8.97 894	132	8.98 002	133	1.01 908	9.99 802	32
	29	8.98 026	131	8.98 225	133	1.01 775	9.99 801	31
	30	8.98 157	131	8.98 358	132	1.01 642	9.99 800	30
	31	8.98 288	131	8.98 490	132	1.01 510	9.99 798	29
	32	8.98 419	130	8.98 622	131	1.01 378	9.99 797	28
	33	8.98 549	130	8.98 753	131	1.01 247	9.99 796	27
	34	8.98 679	129	8.98 884	131	1.01 116	9.99 795	26
	35	8.98 808	129	8.99 015	130	1.00 985	9.99 793	25
	36	8.98 937	129	8.99 145	130	1.00 855	9.99 792	24
	37	8.99 066	128	8.99 275	130	1.00 725	9.99 791	23
	38	8.99 194	128	8.99 405	129	1.00 595	9.99 790	22
	39	8.99 322	128	8.99 534	128	1.00 466	9.99 788	21
	40	8.99 450	127	8.99 662	129	1.00 338	9.99 787	20
	41	8.99 577	127	8.99 791	128	1.00 209	9.99 786	19
	42	8.99 704	126	8.99 919	127	1.00 081	9.99 785	18
	43	8.99 830	126	9.00 046	128	0.99 954	9.99 783	17
	44	8.99 956	126	9.00 174	127	0.99 826	9.99 782	16
	45	9.00 082	125	9.00 301	126	0.99 699	9.99 781	15
	46	9.00 207	125	9.00 427	126	0.99 573	9.99 780	14
	47	9.00 332	124	9.00 553	126	0.99 447	9.99 778	13
	48	9.00 456	125	9.00 679	126	0.99 321	9.99 777	12
	49	9.00 581	123	9.00 805	125	0.99 195	9.99 776	11
	50	9.00 704	124	9.00 930	125	0.99 070	9.99 775	10
	51	9.00 828	123	9.01 055	124	0.98 945	9.99 773	9
	52	9.00 951	123	9.01 179	124	0.98 821	9.99 772	8
	53	9.01 074	122	9.01 303	124	0.98 697	9.99 771	7
	54	9.01 196	122	9.01 427	123	0.98 573	9.99 769	6
	55	9.01 318	122	9.01 550	123	0.98 450	9.99 768	5
	56	9.01 440	121	9.01 673	123	0.98 327	9.99 767	4
	57	9.01 561	121	9.01 796	122	0.98 204	9.99 765	3
	58	9.01 682	121	9.01 918	122	0.98 082	9.99 764	2
	59	9.01 803	120	9.02 040	122	0.97 960	9.99 763	1
	60	9.01 923		9.02 162		0.97 838	9.99 761	0
		L SIN	D	L TAN	CD	L COT	L COS	
		L COS		L COT		L TAN	L SIN	
								354° ..174°
								264° ...84°

6° ..186°		L SIN	D	L TAN	CD	L COT	L COS	
96° ..276°		L COS		L COT		L TAN	L SIN	
	0	9.01 923	120	9.02 162	121	0.97 838	9.99 761	60
	1	9.02 043		9.02 283		0.97 717	9.99 760	59
	2	9.02 163		9.02 404		0.97 596	9.99 759	58
	3	9.02 283		9.02 525		0.97 475	9.99 757	57
	4	9.02 402	119	9.02 645	120	0.97 355	9.99 756	56
	5	9.02 520	118	9.02 766	121	0.97 234	9.99 755	55
	6	9.02 639	119	9.02 885	119	0.97 115	9.99 753	54
	7	9.02 757	118	9.03 005	120	0.96 995	9.99 752	53
	8	9.02 874	117	9.03 124	119	0.96 876	9.99 751	52
	9	9.02 992	118	9.03 242	118	0.96 758	9.99 749	51
	10	9.03 109	117	9.03 361	119	0.96 639	9.99 748	50
	11	9.03 226	117	9.03 479	118	0.96 521	9.99 747	49
	12	9.03 423	116	9.03 597	118	0.96 403	9.99 745	48
	13	9.03 458	116	9.03 714	117	0.96 286	9.99 744	47
	14	9.03 574	116	9.03 832	118	0.96 168	9.99 742	46
	15	9.03 690	116	9.03 948	116	0.96 052	9.99 741	45
	16	9.03 805	115	9.04 065	117	0.95 935	9.99 740	44
	17	9.03 920	115	9.04 181	116	0.95 819	9.99 738	43
	18	9.04 034	114	9.04 297	116	0.95 703	9.99 737	42
	19	9.04 149	115	9.04 413	116	0.95 587	9.99 736	41
	20	9.04 262	113	9.04 528	115	0.95 472	9.99 734	40
	21	9.04 376	114	9.04 643	115	0.95 357	9.99 733	39
	22	9.04 490	114	9.04 758	115	0.95 242	9.99 731	38
	23	9.04 603	113	9.04 873	115	0.95 127	9.99 730	37
	24	9.04 715	112	9.04 987	114	0.95 013	9.99 728	36
	25	9.04 828	113	9.05 101	114	0.94 899	9.99 727	35
	26	9.04 940	112	9.05 214	113	0.94 786	9.99 726	34
	27	9.05 052	112	9.05 328	114	0.94 672	9.99 724	33
	28	9.05 164	112	9.05 441	113	0.94 559	9.99 723	32
	29	9.05 275	111	9.05 553	112	0.94 447	9.99 721	31
	30	9.05 386	111	9.05 666	113	0.94 334	9.99 720	30
	31	9.05 497	111	9.05 778	112	0.94 222	9.99 718	29
	32	9.05 607	110	9.05 890	112	0.94 110	9.99 717	28
	33	9.05 717	110	9.06 002	112	0.93 998	9.99 716	27
	34	9.05 827	110	9.06 113	111	0.93 887	9.99 714	26
	35	9.05 937	110	9.06 224	111	0.93 776	9.99 713	25
	36	9.06 046	109	9.06 335	111	0.93 665	9.99 711	24
	37	9.06 155	109	9.06 445	110	0.93 555	9.99 710	23
	38	9.06 264	109	9.06 556	111	0.93 444	9.99 708	22
	39	9.06 372	108	9.06 666	110	0.93 334	9.99 707	21
	40	9.06 481	109	9.06 775	109	0.93 225	9.99 705	20
	41	9.06 589	108	9.06 885	110	0.93 115	9.99 704	19
	42	9.06 696	107	9.06 994	109	0.93 006	9.99 702	18
	43	9.06 804	108	9.07 103	109	0.92 897	9.99 701	17
	44	9.06 911	107	9.07 211	108	0.92 789	9.99 699	16
	45	9.07 018	107	9.07 320	109	0.92 680	9.99 698	15
	46	9.07 124	106	9.07 428	108	0.92 572	9.99 696	14
	47	9.07 231	107	9.07 536	108	0.92 464	9.99 695	13
	48	9.07 337	106	9.07 643	107	0.92 357	9.99 693	12
	49	9.07 442	105	9.07 751	108	0.92 249	9.99 692	11
	50	9.07 548	106	9.07 858	107	0.92 142	9.99 690	10
	51	9.07 653	105	9.07 964	106	0.92 036	9.99 689	9
	52	9.07 758	105	9.08 071	107	0.91 929	9.99 687	8
	53	9.07 863	105	9.08 177	106	0.91 823	9.99 686	7
	54	9.07 968	105	9.08 283	106	0.91 717	9.99 684	6
	55	9.08 072	104	9.08 389	106	0.91 611	9.99 683	5
	56	9.08 176	104	9.08 495	106	0.91 505	9.99 681	4
	57	9.08 280	104	9.08 600	105	0.91 400	9.99 680	3
	58	9.08 383	103	9.08 706	105	0.91 295	9.99 678	2
	59	9.08 486	103	9.08 810	105	0.91 190	9.99 677	1
	60	9.08 589	103	9.08 914	104	0.91 086	9.99 675	0
		L SIN	D	L TAN	CD	L COT	L COS	
		L COS		L COT		L TAN	L SIN	
								353° ..173°
								263° ...83°

7° ..187°		L SIN		L TAN		L COT	L COS	
97° ..277°		L COS		L COT		L TAN	L SIN	
	0	9.08 589		9.08 914	105	0.91 086	9.99 675	60
	1	9.08 692	103	9.09 019	104	0.90 981	9.99 674	59
	2	9.08 795	103	9.09 123	104	0.90 877	9.99 672	58
	3	9.08 897	102	9.09 227	103	0.90 773	9.99 670	57
	4	9.08 999	102	9.09 330	103	0.90 670	9.99 669	56
			102		104			
	5	9.09 101		9.09 434		0.90 566	9.99 667	55
	6	9.09 202	101	9.09 537	103	0.90 463	9.99 666	54
	7	9.09 304	102	9.09 640	103	0.90 360	9.99 664	53
	8	9.09 405	101	9.09 742	102	0.90 258	9.99 663	52
	9	9.09 506	101	9.09 845	103	0.90 155	9.99 661	51
			100		102			
	10	9.09 606		9.09 947		0.90 053	9.99 659	50
	11	9.09 707	101	9.10 049	102	0.89 951	9.99 658	49
	12	9.09 807	100	9.10 150	101	0.89 850	9.99 656	48
	13	9.09 907	100	9.10 252	102	0.89 748	9.99 655	47
	14	9.10 006	99	9.10 353	101	0.89 647	9.99 653	46
			100		101			
	15	9.10 106		9.10 454		0.89 546	9.99 651	45
	16	9.10 205	99	9.10 555	101	0.89 445	9.99 650	44
	17	9.10 304	99	9.10 666	101	0.89 344	9.99 648	43
	18	9.10 402	98	9.10 766	100	0.89 244	9.99 647	42
	19	9.10 501	99	9.10 856	100	0.89 144	9.99 645	41
			98		100			
	20	9.10 599		9.10 956		0.89 044	9.99 643	40
	21	9.10 697	98	9.11 056	100	0.88 944	9.99 642	39
	22	9.10 795	98	9.11 155	99	0.88 845	9.99 640	38
	23	9.10 893	98	9.11 254	99	0.88 746	9.99 638	37
	24	9.10 990	97	9.11 353	99	0.88 647	9.99 637	36
			97		99			
	25	9.11 087		9.11 452		0.88 548	9.99 635	35
	26	9.11 184	97	9.11 551	99	0.88 449	9.99 633	34
	27	9.11 281	97	9.11 649	98	0.88 351	9.99 632	33
	28	9.11 377	96	9.11 747	98	0.88 253	9.99 630	32
	29	9.11 474	97	9.11 845	98	0.88 155	9.99 629	31
			96		98			
	30	9.11 570		9.11 943		0.88 057	9.99 627	30
	31	9.11 666	96	9.12 040	97	0.87 960	9.99 625	29
	32	9.11 761	95	9.12 138	98	0.87 862	9.99 624	28
	33	9.11 857	96	9.12 235	97	0.87 765	9.99 622	27
	34	9.11 952	95	9.12 332	97	0.87 668	9.99 620	26
			95		96			
	35	9.12 047		9.12 428		0.87 572	9.99 618	25
	36	9.12 142	95	9.12 525	97	0.87 475	9.99 617	24
	37	9.12 236	94	9.12 621	96	0.87 379	9.99 615	23
	38	9.12 331	95	9.12 717	96	0.87 283	9.99 613	22
	39	9.12 425	94	9.12 813	96	0.87 187	9.99 612	21
			94		96			
	40	9.12 519		9.12 909		0.87 091	9.99 610	20
	41	9.12 612	93	9.13 004	95	0.86 996	9.99 608	19
	42	9.12 706	94	9.13 099	95	0.86 901	9.99 607	18
	43	9.12 799	93	9.13 194	95	0.86 806	9.99 605	17
	44	9.12 892	93	9.13 289	95	0.86 711	9.99 603	16
			93		95			
	45	9.12 985		9.13 384		0.86 616	9.99 601	15
	46	9.13 078	93	9.13 478	94	0.86 522	9.99 600	14
	47	9.13 171	93	9.13 573	95	0.86 427	9.99 598	13
	48	9.13 263	92	9.13 667	94	0.86 333	9.99 596	12
	49	9.13 355	92	9.13 761	94	0.86 239	9.99 595	11
			92		93			
	50	9.13 447		9.13 854		0.86 146	9.99 593	10
	51	9.13 539	92	9.13 948	94	0.86 052	9.99 591	9
	52	9.13 630	91	9.14 041	93	0.85 959	9.99 589	8
	53	9.13 772	92	9.14 134	93	0.85 866	9.99 588	7
	54	9.13 813	91	9.14 227	93	0.85 773	9.99 586	6
			91		93			
	55	9.13 904		9.14 320		0.85 680	9.99 584	5
	56	9.13 994	90	9.14 412	92	0.85 588	9.99 582	4
	57	9.14 085	91	9.14 504	92	0.85 496	9.99 581	3
	58	9.14 175	90	9.14 597	93	0.85 403	9.99 579	2
	59	9.14 266	91	9.14 688	91	0.85 312	9.99 577	1
			90		92			
	60	9.14 356		9.14 780		0.85 220	9.99 575	0
		L SIN		L TAN		L COT	L COS	352° ..172°
		L COS	D	L COT	CD	L TAN	L SIN	262° ...82°

8° ..188°		L SIN	D	L TAN	CD	L COT	L COS	
98° ..278°		L COS		L COT		L TAN	L SIN	
	0	9.14 356	89 90 89 90 89	9.14 780	92 91 91 91 91	0.85 220	9.99 575	60
	1	9.14 445		9.14 872		0.85 128	9.99 574	59
	2	9.14 535		9.14 963		0.85 037	9.99 572	58
	3	9.14 624		9.15 054		0.84 946	9.99 570	57
	4	9.14 714		9.15 145		0.84 855	9.99 568	56
	5	9.14 803	88 89 89 88 88	9.15 236	91 90 91 90 90	0.84 764	9.99 566	55
	6	9.14 891		9.15 327		0.84 673	9.99 565	54
	7	9.14 980		9.15 417		0.84 583	9.99 563	53
	8	9.15 069		9.15 508		0.84 492	9.99 561	52
	9	9.15 157		9.15 598		0.84 402	9.99 559	51
	10	9.15 245	88 88 87 88 87	9.15 688	89 90 89 90 89	0.84 312	9.99 557	50
	11	9.15 333		9.15 777		0.84 223	9.99 556	49
	12	9.15 421		9.15 867		0.84 133	9.99 554	48
	13	9.15 508		9.15 956		0.84 044	9.99 552	47
	14	9.15 596		9.16 046		0.83 954	9.99 550	46
	15	9.15 683	87 87 87 86 86	9.16 135	88 88 89 88 88	0.83 865	9.99 548	45
	16	9.15 770		9.16 224		0.83 776	9.99 546	44
	17	9.15 857		9.16 312		0.83 688	9.99 545	43
	18	9.15 944		9.16 401		0.83 599	9.99 543	42
	19	9.16 030		9.16 489		0.83 511	9.99 541	41
	20	9.16 116	87 86 85 86 85	9.16 577	88 88 88 87 88	0.83 423	9.99 539	40
	21	9.16 203		9.16 665		0.83 335	9.99 537	39
	22	9.16 289		9.16 753		0.83 247	9.99 535	38
	23	9.16 374		9.16 841		0.83 159	9.99 533	37
	24	9.16 460		9.16 928		0.83 072	9.99 532	36
	25	9.16 545	86 85 85 85 84	9.17 016	87 87 87 86 87	0.82 984	9.99 530	35
	26	9.16 631		9.17 103		0.82 897	9.99 528	34
	27	9.16 716		9.17 190		0.82 810	9.99 526	33
	28	9.16 801		9.17 277		0.82 723	9.99 524	32
	29	9.16 886		9.17 363		0.82 637	9.99 522	31
	30	9.16 970	85 84 84 84 84	9.17 450	86 86 86 86 86	0.82 550	9.99 520	30
	31	9.17 055		9.17 536		0.82 464	9.99 518	29
	32	9.17 139		9.17 622		0.82 378	9.99 517	28
	33	9.17 223		9.17 708		0.82 292	9.99 515	27
	34	9.17 307		9.17 794		0.82 206	9.99 513	26
	35	9.17 391	83 84 83 83 83	9.17 880	85 86 85 85 85	0.82 120	9.99 511	25
	36	9.17 474		9.17 965		0.82 035	9.99 509	24
	37	9.17 558		9.18 051		0.81 949	9.99 507	23
	38	9.17 641		9.18 136		0.81 864	9.99 505	22
	39	9.17 724		9.18 221		0.81 779	9.99 503	21
	40	9.17 807	83 83 82 82 83	9.18 306	85 84 85 84 84	0.81 694	9.99 501	20
	41	9.17 890		9.18 391		0.81 609	9.99 499	19
	42	9.17 973		9.18 475		0.81 525	9.99 497	18
	43	9.18 055		9.18 560		0.81 440	9.99 495	17
	44	9.18 137		9.18 644		0.81 356	9.99 494	16
	45	9.18 220	82 81 82 82 81	9.18 728	84 84 83 84 83	0.81 272	9.99 492	15
	46	9.18 302		9.18 812		0.81 188	9.99 490	14
	47	9.18 383		9.18 896		0.81 104	9.99 488	13
	48	9.18 465		9.18 979		0.81 021	9.99 486	12
	49	9.18 547		9.19 063		0.80 937	9.99 484	11
	50	9.18 628	81 81 81 81 81	9.19 146	83 83 83 83 83	0.80 854	9.99 482	10
	51	9.18 709		9.19 229		0.80 771	9.99 480	9
	52	9.18 790		9.19 342		0.80 688	9.99 478	8
	53	9.18 871		9.19 395		0.80 605	9.99 476	7
	54	9.18 952		9.19 478		0.80 522	9.99 474	6
	55	9.19 033	80 80 80 80 80	9.19 561	82 82 82 82 82	0.80 439	9.99 472	5
	56	9.19 113		9.19 643		0.80 357	9.99 470	4
	57	9.19 193		9.19 725		0.80 275	9.99 468	3
	58	9.19 273		9.19 807		0.80 193	9.99 466	2
	59	9.19 353		9.19 889		0.80 111	9.99 464	1
	60	9.19 433		9.19 971		0.80 029	9.99 462	0
		L SIN	D	L TAN	CD	L COT	L COS	
		L COS		L COT		L TAN	L SIN	
								351° ..171°
								261° ...81°

9° ..189°		L SIN	D	L TAN	CD	L COT	L COS	
99° ..279°		L COS		L COT		L TAN	L SIN	
	0	9.19 433	80	9.19 971	82	0.80 029	9.99 462	60
	1	9.19 513	79	9.20 053	81	0.79 947	9.99 460	59
	2	9.19 592	80	9.20 134	82	0.79 866	9.99 458	58
	3	9.19 672	79	9.20 216	81	0.79 784	9.99 456	57
	4	9.19 751	79	9.20 297	81	0.79 703	9.99 454	56
	5	9.19 830	79	9.20 378	81	0.79 622	9.99 452	55
	6	9.19 909	79	9.20 459	81	0.79 541	9.99 450	54
	7	9.19 988	79	9.20 540	81	0.79 460	9.99 448	53
	8	9.20 067	78	9.20 621	80	0.79 379	9.99 446	52
	9	9.20 145	78	9.20 701	81	0.79 299	9.99 444	51
	10	9.20 223	79	9.20 782	80	0.79 218	9.99 442	50
	11	9.20 302	78	9.20 862	80	0.79 138	9.99 440	49
	12	9.20 380	78	9.20 942	80	0.79 058	9.99 438	48
	13	9.20 458	77	9.21 022	80	0.78 978	9.99 436	47
	14	9.20 535	78	9.21 102	80	0.78 898	9.99 434	46
	15	9.20 613	78	9.21 182	79	0.78 818	9.99 432	45
	16	9.20 691	77	9.21 261	80	0.78 739	9.99 429	44
	17	9.20 768	77	9.21 341	79	0.78 659	9.99 427	43
	18	9.20 845	77	9.21 420	79	0.78 580	9.99 425	42
	19	9.20 922	77	9.21 499	79	0.78 501	9.99 423	41
	20	9.20 999	77	9.21 578	79	0.78 422	9.99 421	40
	21	9.21 076	77	9.21 657	79	0.78 343	9.99 419	39
	22	9.21 153	76	9.21 736	78	0.78 264	9.99 417	38
	23	9.21 229	77	9.21 814	79	0.78 186	9.99 415	37
	24	9.21 306	76	9.21 893	78	0.78 107	9.99 413	36
	25	9.21 382	76	9.21 971	78	0.78 029	9.99 411	35
	26	9.21 458	76	9.22 049	78	0.77 951	9.99 409	34
	27	9.21 534	76	9.22 127	78	0.77 873	9.99 407	33
	28	9.21 610	75	9.22 205	78	0.77 795	9.99 404	32
	29	9.21 685	76	9.22 283	78	0.77 717	9.99 402	31
	30	9.21 761	75	9.22 361	77	0.77 639	9.99 400	30
	31	9.21 836	76	9.22 438	78	0.77 562	9.99 398	29
	32	9.21 912	75	9.22 516	77	0.77 484	9.99 396	28
	33	9.21 987	75	9.22 593	77	0.77 407	9.99 394	27
	34	9.22 062	75	9.22 670	77	0.77 330	9.99 392	26
	35	9.22 137	74	9.22 747	77	0.77 253	9.99 390	25
	36	9.22 211	75	9.22 824	77	0.77 176	9.99 388	24
	37	9.22 286	75	9.22 901	76	0.77 099	9.99 385	23
	38	9.22 361	74	9.22 977	77	0.77 023	9.99 383	22
	39	9.22 435	74	9.23 054	76	0.76 945	9.99 381	21
	40	9.22 509	74	9.23 130	76	0.76 870	9.99 379	20
	41	9.22 583	74	9.23 206	77	0.76 794	9.99 377	19
	42	9.22 657	74	9.23 283	76	0.76 717	9.99 375	18
	43	9.22 731	74	9.23 359	76	0.76 641	9.99 372	17
	44	9.22 805	73	9.23 435	75	0.76 565	9.99 370	16
	45	9.22 878	74	9.23 510	76	0.76 490	9.99 368	15
	46	9.22 952	73	9.23 586	75	0.76 414	9.99 366	14
	47	9.23 025	73	9.23 661	76	0.76 339	9.99 364	13
	48	9.23 098	73	9.23 737	75	0.76 263	9.99 362	12
	49	9.23 171	73	9.23 812	75	0.76 188	9.99 359	11
	50	9.23 244	73	9.23 887	75	0.76 113	9.99 357	10
	51	9.23 317	73	9.23 962	75	0.76 038	9.99 355	9
	52	9.23 390	72	9.24 037	75	0.75 963	9.99 353	8
	53	9.23 462	73	9.24 112	74	0.75 888	9.99 351	7
	54	9.23 535	72	9.24 186	75	0.75 814	9.99 348	6
	55	9.23 607	72	9.24 261	74	0.75 739	9.99 346	5
	56	9.23 679	73	9.24 335	75	0.75 665	9.99 344	4
	57	9.23 752	71	9.24 410	74	0.75 590	9.99 342	3
	58	9.23 823	72	9.24 484	74	0.75 516	9.99 340	2
	59	9.23 895	72	9.24 558	74	0.75 442	9.99 337	1
	60	9.23 967		9.24 632		0.75 368	9.99 335	0
		L SIN	D	L TAN	CD	L COT	L COS	350° ..170°
		L COS		L COT		L TAN	L SIN	260° ...80°

10° ..190°		L SIN	D	L TAN	CD	L COT	L COS	
100° ..280°		L COS		L COT		L TAN	L SIN	
	0	9.23 967	72	9.24 632	74	0.75 368	9.99 335	60
	1	9.24 039		9.24 706		0.75 294	9.99 333	59
	2	9.24 110		9.24 779		0.75 221	9.99 331	58
	3	9.24 181		9.24 853		0.75 147	9.99 328	57
	4	9.24 253	72	9.24 926	73	0.75 074	9.99 326	56
			71		74			
	5	9.24 324	71	9.25 000	73	0.75 000	9.99 324	55
	6	9.24 395		9.25 073		0.74 927	9.99 322	54
	7	9.24 466		9.25 146		0.74 854	9.99 319	53
	8	9.24 536		9.25 219		0.74 781	9.99 317	52
	9	9.24 607	71	9.25 292	73	0.74 708	9.99 315	51
			70		73			
	10	9.24 677	71	9.25 365	72	0.74 635	9.99 313	50
	11	9.24 748		9.25 437		0.74 563	9.99 310	49
	12	9.24 818		9.25 510		0.74 490	9.99 308	48
	13	9.24 888		9.25 582		0.74 418	9.99 306	47
	14	9.24 958	70	9.25 655	73	0.74 345	9.99 304	46
			70		72			
	15	9.25 028	70	9.25 727	72	0.74 273	9.99 301	45
	16	9.25 098		9.25 799		0.74 201	9.99 299	44
	17	9.25 168		9.25 871		0.74 129	9.99 297	43
	18	9.25 237		9.25 943		0.74 057	9.99 294	42
	19	9.25 307	70	9.26 015	72	0.73 985	9.99 292	41
			69		71			
	20	9.25 376	69	9.26 086	72	0.73 914	9.99 290	40
	21	9.25 445		9.26 158		0.73 842	9.99 288	39
	22	9.25 514		9.26 229		0.73 771	9.99 285	38
	23	9.25 583		9.26 301		0.73 699	9.99 283	37
	24	9.25 652	69	9.26 372	71	0.73 628	9.99 281	36
			69		71			
	25	9.25 721	69	9.26 443	71	0.73 557	9.99 278	35
	26	9.25 790		9.26 514		0.73 486	9.99 276	34
	27	9.25 858		9.26 585		0.73 415	9.99 274	33
	28	9.25 927		9.26 665		0.73 345	9.99 271	32
	29	9.25 995	68	9.26 726	71	0.73 274	9.99 269	31
			68		71			
	30	9.26 063	68	9.26 797	70	0.73 203	9.99 267	30
	31	9.26 131		9.26 867		0.73 133	9.99 264	29
	32	9.26 199		9.26 937		0.73 063	9.99 262	28
	33	9.26 267		9.27 008		0.72 992	9.99 260	27
	34	9.26 335	68	9.27 078	70	0.72 922	9.99 257	26
			68		70			
	35	9.26 403	67	9.27 148	70	0.72 852	9.99 255	25
	36	9.26 470		9.27 218		0.72 782	9.99 252	24
	37	9.26 538		9.27 288		0.72 712	9.99 250	23
	38	9.26 605		9.27 357		0.72 643	9.99 248	22
	39	9.26 672	67	9.27 427	70	0.72 573	9.99 245	21
			67		69			
	40	9.26 739	67	9.27 496	70	0.72 504	9.99 243	20
	41	9.26 806		9.27 566		0.72 434	9.99 241	19
	42	9.26 873		9.27 635		0.72 365	9.99 238	18
	43	9.26 940		9.27 704		0.72 296	9.99 236	17
	44	9.27 007	67	9.27 773	69	0.72 227	9.99 233	16
			66		69			
	45	9.27 073	67	9.27 842	69	0.72 158	9.99 231	15
	46	9.27 140		9.27 911		0.72 089	9.99 229	14
	47	9.27 206		9.27 980		0.72 020	9.99 226	13
	48	9.27 273		9.28 049		0.71 951	9.99 224	12
	49	9.27 339	66	9.28 117	68	0.71 883	9.99 221	11
			66		69			
	50	9.27 405	66	9.28 186	68	0.71 814	9.99 219	10
	51	9.27 471		9.28 254		0.71 746	9.99 217	9
	52	9.27 537		9.28 323		0.71 677	9.99 214	8
	53	9.27 602		9.28 391		0.71 609	9.99 212	7
	54	9.27 668	65	9.28 459	68	0.71 541	9.99 209	6
			66		68			
	55	9.27 734	65	9.28 527	68	0.71 473	9.99 207	5
	56	9.27 799		9.28 595		0.71 405	9.99 204	4
	57	9.27 864		9.28 662		0.71 338	9.99 202	3
	58	9.27 930		9.28 730		0.71 270	9.99 200	2
	59	9.27 995	65	9.28 798	68	0.71 202	9.99 197	1
			65		67			
	60	9.28 060		9.28 865		0.71 135	9.99 195	0
		L SIN	D	L TAN	CD	L COT	L COS	
		L COS		L COT		L TAN	L SIN	
								349° ..169°
								259° ...79°

11° ..191°		L SIN	D	L TAN	CD	L COT	L COS	
101° ..281°		L COS		L COT		L TAN	L SIN	
	0	9.28 060	65	9.28 865	68	0.71 135	9.99 195	60
	1	9.28 125	65	9.28 933	67	0.71 067	9.99 192	59
	2	9.28 190	64	9.29 000	67	0.71 000	9.99 190	58
	3	9.28 254	65	9.29 067	67	0.70 933	9.99 187	57
	4	9.28 319	65	9.29 134	67	0.70 866	9.99 185	56
	5	9.28 384	64	9.29 201	67	0.70 799	9.99 182	55
	6	9.28 448	6	9.29 268	67	0.70 732	9.99 180	54
	7	9.28 512	65	9.29 335	67	0.70 665	9.99 177	53
	8	9.28 577	64	9.29 402	66	0.70 598	9.99 175	52
	9	9.28 641	64	9.29 468	67	0.70 532	9.99 172	51
	10	9.28 705	64	9.29 535	66	0.70 465	9.99 170	50
	11	9.28 769	64	9.29 601	67	0.70 399	9.99 167	49
	12	9.28 833	63	9.29 668	66	0.70 332	9.99 165	48
	13	9.28 896	64	9.29 734	66	0.70 266	9.99 162	47
	14	9.28 960	64	9.29 800	66	0.70 200	9.99 160	46
	15	9.29 02	63	9.29 866	66	0.70 134	9.99 157	45
	16	9.29 087	63	9.29 932	66	0.70 068	9.99 155	44
	17	9.29 150	64	9.29 998	66	0.70 002	9.99 152	43
	18	9.29 214	63	9.30 064	66	0.69 936	9.99 150	42
	19	9.29 277	63	9.30 130	65	0.69 870	9.99 147	41
	20	9.29 340	63	9.30 195	66	0.69 805	9.99 145	40
	21	9.29 403	63	9.30 261	65	0.69 739	9.99 142	39
	22	9.29 466	63	9.30 326	65	0.69 674	9.99 140	38
	23	9.29 529	62	9.30 391	66	0.69 609	9.99 137	37
	24	9.29 591	63	9.30 457	65	0.69 543	9.99 135	36
	25	9.29 654	62	9.30 522	65	0.69 478	9.99 132	35
	26	9.29 716	63	9.30 587	65	0.69 413	9.99 130	34
	27	9.29 779	62	9.30 652	65	0.69 348	9.99 127	33
	28	9.29 841	62	9.30 717	65	0.69 283	9.99 124	32
	29	9.29 903	63	9.30 782	64	0.69 218	9.99 122	31
	30	9.29 966	62	9.30 846	65	0.69 154	9.99 119	30
	31	9.30 028	62	9.30 911	64	0.69 089	9.99 117	29
	32	9.30 090	61	9.30 975	65	0.69 025	9.99 114	28
	33	9.30 151	62	9.31 040	64	0.68 960	9.99 112	27
	34	9.30 213	62	9.31 104	64	0.68 896	9.99 109	26
	35	9.30 275	61	9.31 168	65	0.68 832	9.99 106	25
	36	9.30 336	62	9.31 233	64	0.68 767	9.99 104	24
	37	9.30 398	61	9.31 297	64	0.68 703	9.99 101	23
	38	9.30 459	62	9.31 361	64	0.68 639	9.99 099	22
	39	9.30 521	61	9.31 425	64	0.68 575	9.99 096	21
	40	9.30 582	61	9.31 489	63	0.68 511	9.99 093	20
	41	9.30 643	61	9.31 552	64	0.68 448	9.99 091	19
	42	9.30 704	61	9.31 616	63	0.68 384	9.99 088	18
	43	9.30 765	61	9.31 679	64	0.68 321	9.99 086	17
	44	9.30 826	61	9.31 743	63	0.68 257	9.99 083	16
	45	9.30 887	60	9.31 806	64	0.68 194	9.99 080	15
	46	9.30 947	61	9.31 870	63	0.68 130	9.99 078	14
	47	9.31 008	60	9.31 933	63	0.68 067	9.99 075	13
	48	9.31 068	61	9.31 996	63	0.68 004	9.99 072	12
	49	9.31 129	60	9.32 059	63	0.67 941	9.99 070	11
	50	9.31 189	61	9.32 122	63	0.67 878	9.99 067	10
	51	9.31 250	60	9.32 185	63	0.67 815	9.99 064	9
	52	9.31 310	60	9.32 248	63	0.67 752	9.99 062	8
	53	9.31 370	60	9.32 311	62	0.67 689	9.99 059	7
	54	9.31 430	60	9.32 373	63	0.67 627	9.99 056	6
	55	9.31 490	59	9.32 436	62	0.67 564	9.99 054	5
	56	9.31 549	60	9.32 498	63	0.67 502	9.99 051	4
	57	9.31 609	60	9.32 561	62	0.67 439	9.99 048	3
	58	9.31 669	59	9.32 623	62	0.67 377	9.99 046	2
	59	9.31 728	60	9.32 685	62	0.67 315	9.99 043	1
	60	9.31 788		9.32 747		0.67 253	9.99 040	0
		L SIN	D	L TAN	CD	L COT	L COS	348° ..168°
		L COS		L COT		L TAN	L SIN	258° ...78°

12° ... 192°		L SIN	D	L TAN	CD	L COT	L COS	
102° ... 282°		L COS		L COT		L TAN	L SIN	
	0	9.31 788	59	9.32 747	63	0.67 253	9.99 040	60
	1	9.31 847	60	9.32 810	62	0.67 190	9.99 038	59
	2	9.31 907	59	9.32 872	61	0.67 128	9.99 035	58
	3	9.31 966	59	9.32 933	62	0.67 067	9.99 032	57
	4	9.32 025	59	9.32 995	62	0.67 005	9.99 030	56
	5	9.32 084	59	9.33 057	62	0.66 943	9.99 027	55
	6	9.32 143	59	9.33 119	61	0.66 881	9.99 024	54
	7	9.32 202	59	9.33 180	62	0.66 820	9.99 022	53
	8	9.32 261	58	9.33 242	61	0.66 758	9.99 019	52
	9	9.32 319	59	9.33 303	62	0.66 697	9.99 016	51
	10	9.32 378	59	9.33 365	61	0.66 635	9.99 013	50
	11	9.32 437	58	9.33 426	61	0.66 574	9.99 011	49
	12	9.32 495	58	9.33 487	61	0.66 513	9.99 008	48
	13	9.32 553	59	9.33 548	61	0.66 452	9.99 005	47
	14	9.32 612	58	9.33 609	61	0.66 391	9.99 002	46
	15	9.32 670	58	9.33 670	61	0.66 330	9.99 000	45
	16	9.32 728	58	9.33 731	61	0.66 269	9.98 997	44
	17	9.32 786	58	9.33 792	61	0.66 208	9.98 994	43
	18	9.32 844	58	9.33 853	60	0.66 147	9.98 991	42
	19	9.32 902	5	9.33 913	61	0.66 087	9.98 989	41
	20	9.32 960	58	9.33 974	60	0.66 026	9.98 986	40
	21	9.33 018	57	9.34 034	61	0.65 966	9.98 983	39
	22	9.33 075	58	9.34 095	60	0.65 905	9.98 980	38
	23	9.33 133	57	9.34 155	60	0.65 845	9.98 978	37
	24	9.33 190	58	9.34 215	61	0.65 785	9.98 975	36
	25	9.33 248	57	9.34 276	60	0.65 724	9.98 972	35
	26	9.33 305	57	9.34 336	60	0.65 664	9.98 969	34
	27	9.33 362	58	9.34 396	60	0.65 604	9.98 967	33
	28	9.33 420	57	9.34 456	60	0.65 544	9.98 964	32
	29	9.33 477	57	9.34 516	60	0.65 484	9.98 961	31
	30	9.33 534	57	9.34 576	59	0.65 424	9.98 958	30
	31	9.33 591	56	9.34 635	60	0.65 365	9.98 955	29
	32	9.33 647	57	9.34 695	60	0.65 305	9.98 953	28
	33	9.33 704	57	9.34 755	59	0.65 245	9.98 950	27
	34	9.33 761	57	9.34 814	60	0.65 186	9.98 947	26
	35	9.33 818	56	9.34 874	59	0.65 126	9.98 944	25
	36	9.33 874	57	9.34 933	59	0.65 067	9.98 941	24
	37	9.33 931	56	9.34 992	59	0.65 008	9.98 938	23
	38	9.33 987	56	9.35 051	60	0.64 949	9.98 936	22
	39	9.34 043	57	9.35 111	59	0.64 889	9.98 933	21
	40	9.34 100	56	9.35 170	59	0.64 830	9.98 930	20
	41	9.34 156	56	9.35 229	59	0.64 771	9.98 927	19
	42	9.34 212	56	9.35 288	59	0.64 712	9.98 924	18
	43	9.34 268	56	9.35 347	58	0.64 653	9.98 921	17
	44	9.34 324	56	9.35 405	59	0.64 595	9.98 919	16
	45	9.34 380	56	9.35 464	59	0.64 536	9.98 916	15
	46	9.34 436	55	9.35 523	58	0.64 477	9.98 913	14
	47	9.34 491	56	9.35 581	59	0.64 419	9.98 910	13
	48	9.34 547	55	9.35 640	58	0.64 360	9.98 907	12
	49	9.34 602	56	9.35 698	59	0.64 302	9.98 904	11
	50	9.34 658	55	9.35 757	58	0.64 243	9.98 901	10
	51	9.34 713	56	9.35 815	58	0.64 185	9.98 898	9
	52	9.34 769	55	9.35 873	58	0.64 127	9.98 896	8
	53	9.34 824	55	9.35 931	58	0.64 069	9.98 893	7
	54	9.34 879	55	9.35 989	58	0.64 011	9.98 890	6
	55	9.34 934	55	9.36 047	58	0.63 953	9.98 887	5
	56	9.34 989	55	9.36 105	58	0.63 895	9.98 884	4
	57	9.35 044	55	9.36 163	58	0.63 837	9.98 881	3
	58	9.35 099	55	9.36 221	58	0.63 779	9.98 878	2
	59	9.35 154	55	9.36 279	57	0.63 721	9.98 875	1
	60	9.35 209		9.36 336		0.63 664	9.98 872	0
		L SIN	D	L TAN	CD	L COT	L COS	347° ... 167°
		L COS		L COT		L TAN	L SIN	257° ... 77°

13°...193°		L SIN		L TAN		L COT	L COS	
103°...283°		L COS	D	L COT	CD	L TAN	L SIN	
	0	9.35 209		9.36 336		0.63 664	9.98 872	60
	1	9.35 263	54	9.36 394	58	0.63 606	9.98 869	59
	2	9.35 318	55	9.36 452	58	0.63 548	9.98 867	58
	3	9.35 373	55	9.36 509	57	0.63 491	9.98 864	57
	4	9.35 427	54	9.36 566	57	0.63 434	9.98 861	56
			54		58			
	5	9.35 481		9.36 624		0.63 376	9.98 858	55
	6	9.35 536	55	9.36 681	57	0.63 319	9.98 855	54
	7	9.35 590	54	9.36 738	57	0.63 262	9.98 852	53
	8	9.35 644	54	9.36 795	57	0.63 205	9.98 849	52
	9	9.35 698	54	9.36 852	57	0.63 148	9.98 846	51
			54		57			
	10	9.35 752		9.36 909		0.63 091	9.98 843	50
	11	9.35 806	54	9.36 966	57	0.63 034	9.98 840	49
	12	9.35 860	54	9.37 023	57	0.62 977	9.98 837	48
	13	9.35 914	54	9.37 080	57	0.62 920	9.98 834	47
	14	9.35 968	54	9.37 137	57	0.62 863	9.98 831	46
			54		56			
	15	9.36 022		9.37 193		0.62 807	9.98 828	45
	16	9.36 075	53	9.37 250	57	0.62 750	9.98 825	44
	17	9.36 129	54	9.37 306	56	0.62 694	9.98 822	43
	18	9.36 182	53	9.37 363	57	0.62 637	9.98 819	42
	19	9.36 236	54	9.37 419	56	0.62 581	9.98 816	41
			53		57			
	20	9.36 289		9.37 476		0.62 524	9.98 813	40
	21	9.36 342	53	9.37 532	56	0.62 468	9.98 810	39
	22	9.36 395	53	9.37 588	56	0.62 412	9.98 807	38
	23	9.36 449	54	9.37 644	56	0.62 356	9.98 804	37
	24	9.36 502	53	9.37 700	56	0.62 300	9.98 801	36
			53		56			
	25	9.36 555		9.37 756		0.62 244	9.98 798	35
	26	9.36 608	53	9.37 812	56	0.62 188	9.98 795	34
	27	9.36 660	52	9.37 868	56	0.62 132	9.98 792	33
	28	9.36 713	53	9.37 924	56	0.62 076	9.98 789	32
	29	9.36 766	53	9.37 980	56	0.62 020	9.98 786	31
			53		55			
	30	9.36 819		9.38 035		0.61 965	9.98 783	30
	31	9.36 871	52	9.38 091	56	0.61 909	9.98 780	29
	32	9.36 924	53	9.38 147	56	0.61 853	9.98 777	28
	33	9.36 976	52	9.38 202	55	0.61 798	9.98 774	27
	34	9.37 028	52	9.38 257	55	0.61 743	9.98 771	26
			53		56			
	35	9.37 081		9.38 313		0.61 687	9.98 768	25
	36	9.37 133	52	9.38 368	55	0.61 632	9.98 765	24
	37	9.37 185	52	9.38 423	55	0.61 577	9.98 762	23
	38	9.37 237	52	9.38 479	56	0.61 521	9.98 759	22
	39	9.37 289	52	9.38 534	55	0.61 466	9.98 756	21
			52		55			
	40	9.37 341		9.38 589		0.61 411	9.98 753	20
	41	9.37 393	52	9.38 644	55	0.61 356	9.98 750	19
	42	9.37 445	52	9.38 699	55	0.61 301	9.98 746	18
	43	9.37 497	52	9.38 754	55	0.61 246	9.98 743	17
	44	9.37 549	52	9.38 808	54	0.61 192	9.98 740	16
			51		55			
	45	9.37 600		9.38 863		0.61 137	9.98 737	15
	46	9.37 652	52	9.38 918	55	0.61 082	9.98 734	14
	47	9.37 703	51	9.38 972	54	0.61 028	9.98 731	13
	48	9.37 755	52	9.39 027	55	0.60 973	9.98 728	12
	49	9.37 806	51	9.39 082	55	0.60 918	9.98 725	11
			52		54			
	50	9.37 858		9.39 136		0.60 864	9.98 722	10
	51	9.37 909	51	9.39 190	54	0.60 810	9.98 719	9
	52	9.37 960	51	9.39 245	55	0.60 755	9.98 715	8
	53	9.38 011	51	9.39 299	54	0.60 701	9.98 712	7
	54	9.38 062	51	9.39 353	54	0.60 647	9.98 709	6
			51		54			
	55	9.38 113		9.39 407		0.60 593	9.98 706	5
	56	9.38 164	51	9.39 461	54	0.60 539	9.98 703	4
	57	9.38 215	51	9.39 515	54	0.60 485	9.98 700	3
	58	9.38 266	51	9.39 569	54	0.60 431	9.98 697	2
	59	9.38 317	51	9.39 623	54	0.60 377	9.98 694	1
			51		54			
	60	9.38 368		9.39 677		0.60 323	9.98 690	0
		L SIN	D	L TAN	CD	L COT	L COS	346°...166°
		L COS		L COT		L TAN	L SIN	256°...76°

14° ..194°		L SIN	D	L TAN	CD	L COT	L COS	D	
104° ..284°		L COS		L COT		L TAN	L SIN		
	0	9.38 368	50	9.39 677	54	0.60 323	9.98 690	3	60
	1	9.38 418	51	9.39 731	54	0.60 269	9.98 687	3	59
	2	9.38 469	50	9.39 785	53	0.60 215	9.98 684	3	58
	3	9.38 519	51	9.39 838	54	0.60 162	9.98 681	3	57
	4	9.38 570	50	9.39 892	53	0.60 108	9.98 678	3	56
	5	9.38 620	50	9.39 945	54	0.60 055	9.98 675	4	55
	6	9.38 670	51	9.39 999	53	0.60 001	9.98 671	3	54
	7	9.38 721	50	9.40 052	54	0.59 948	9.98 668	3	53
	8	9.38 771	50	9.40 106	53	0.59 894	9.98 665	3	52
	9	9.38 821	50	9.40 159	53	0.59 841	9.98 662	3	51
	10	9.38 871	50	9.40 212	54	0.59 788	9.98 659	3	50
	11	9.38 921	50	9.40 206	53	0.59 734	9.98 656	4	49
	12	9.38 971	50	9.40 319	53	0.59 681	9.98 652	3	48
	13	9.39 021	50	9.40 372	53	0.59 628	9.98 649	3	47
	14	9.39 071	50	9.40 425	53	0.59 575	9.98 646	3	46
	15	9.39 121	49	9.40 478	53	0.59 522	9.98 643	3	45
	16	9.39 170	50	9.40 531	53	0.59 469	9.98 640	4	44
	17	9.39 220	50	9.40 584	52	0.59 416	9.98 636	3	43
	18	9.39 270	49	9.40 636	53	0.59 364	9.98 633	3	42
	19	9.39 319	50	9.40 689	53	0.59 311	9.98 630	3	41
	20	9.39 369	49	9.40 742	53	0.59 258	9.98 627	4	40
	21	9.39 418	49	9.40 795	52	0.59 205	9.98 623	3	39
	22	9.39 467	50	9.40 847	53	0.59 153	9.98 620	3	38
	23	9.39 517	49	9.40 900	52	0.59 100	9.98 617	3	37
	24	9.39 566	49	9.40 952	53	0.59 048	9.98 614	4	36
	25	9.39 615	49	9.41 005	52	0.58 995	9.98 610	3	35
	26	9.39 664	49	9.41 057	52	0.58 943	9.98 607	3	34
	27	9.39 713	49	9.41 109	52	0.58 891	9.98 604	3	33
	28	9.39 762	49	9.41 161	53	0.58 839	9.98 601	4	32
	29	9.39 811	49	9.41 214	52	0.58 786	9.98 597	3	31
	30	9.39 860	49	9.41 266	52	0.58 734	9.98 594	3	30
	31	9.39 909	49	9.41 318	52	0.58 682	9.98 591	3	29
	32	9.39 958	48	9.41 370	52	0.58 630	9.98 588	4	28
	33	9.40 006	49	9.41 422	52	0.58 578	9.98 584	3	27
	34	9.40 055	48	9.41 474	52	0.58 526	9.98 581	3	26
	35	9.40 103	49	9.41 526	52	0.58 474	9.98 578	4	25
	36	9.40 152	48	9.41 578	51	0.58 422	9.98 574	3	24
	37	9.40 200	49	9.41 629	52	0.58 371	9.98 571	3	23
	38	9.40 249	48	9.41 681	52	0.58 319	9.98 568	3	22
	39	9.40 297	49	9.41 733	51	0.58 267	9.98 565	4	21
	40	9.40 346	48	9.41 784	52	0.58 216	9.98 561	3	20
	41	9.40 394	48	9.41 836	51	0.58 164	9.98 558	3	19
	42	9.40 442	48	9.41 887	52	0.58 113	9.98 555	4	18
	43	9.40 490	48	9.41 939	51	0.58 061	9.98 551	3	17
	44	9.40 538	48	9.41 990	51	0.58 010	9.98 548	3	16
	45	9.40 586	48	9.42 041	52	0.57 959	9.98 545	4	15
	46	9.40 634	48	9.42 093	51	0.57 907	9.98 541	3	14
	47	9.40 682	48	9.42 144	51	0.57 856	9.98 538	3	13
	48	9.40 730	48	9.42 195	51	0.57 805	9.98 535	4	12
	49	9.40 778	47	9.42 246	51	0.57 754	9.98 531	3	11
	50	9.40 825	48	9.42 297	51	0.57 703	9.98 528	3	10
	51	9.40 873	48	9.42 348	51	0.57 652	9.98 525	4	9
	52	9.40 921	47	9.42 399	51	0.57 601	9.98 521	3	8
	53	9.40 968	48	9.42 450	51	0.57 550	9.98 518	3	7
	54	9.41 016	47	9.42 501	51	0.57 499	9.98 515	4	6
	55	9.41 063	48	9.42 552	51	0.57 448	9.98 511	3	5
	56	9.41 111	47	9.42 603	50	0.57 397	9.98 508	3	4
	57	9.41 158	47	9.42 653	51	0.57 347	9.98 505	4	3
	58	9.41 205	47	9.42 704	51	0.57 296	9.98 501	3	2
	59	9.41 252	48	9.42 755	50	0.57 245	9.98 498	4	1
	60	9.41 300		9.42 805		0.57 195	9.98 494		0
		L SIN	D	L TAN	CD	L COT	L COS	D	345° ...165°
		L COS		L COT		L TAN	L SIN		255° 75°

15°...195°		L SIN		L TAN		L COT	L COS		
105°...285°		L COS	D	L COT	CD	L TAN	L SIN	D	
	0	9.41 300	47	9.42 805	51	0.57 195	9.98 494	3	60
	1	9.41 347	47	9.42 856	50	0.57 144	9.98 491	3	59
	2	9.41 394	47	9.42 906	51	0.57 094	9.98 488	4	58
	3	9.41 441	47	9.42 957	50	0.57 043	9.98 484	3	57
	4	9.41 488	47	9.43 007	50	0.56 993	9.98 481	3	56
	5	9.41 535	47	9.43 057	51	0.56 943	9.98 477	3	55
	6	9.41 582	46	9.43 108	50	0.56 892	9.98 474	3	54
	7	9.41 628	47	9.43 158	50	0.56 842	9.98 471	4	53
	8	9.41 675	47	9.43 208	50	0.56 792	9.98 467	3	52
	9	9.41 722	46	9.43 258	50	0.56 742	9.98 464	4	51
	10	9.41 768	47	9.43 308	50	0.56 692	9.98 460	3	50
	11	9.41 815	46	9.43 358	50	0.56 642	9.98 457	4	49
	12	9.41 861	47	9.43 408	50	0.56 592	9.98 453	3	48
	13	9.41 908	46	9.43 458	50	0.56 542	9.98 450	3	47
	14	9.41 954	47	9.43 508	50	0.56 492	9.98 447	4	46
	15	9.42 001	46	9.43 558	49	0.56 442	9.98 443	3	45
	16	9.42 047	46	9.43 607	50	0.56 393	9.98 440	4	44
	17	9.42 093	47	9.43 657	50	0.56 343	9.98 436	3	43
	18	9.42 140	46	9.43 707	49	0.56 293	9.98 433	4	42
	19	9.42 186	46	9.43 756	50	0.56 244	9.98 429	3	41
	20	9.42 232	46	9.43 806	49	0.56 194	9.98 426	4	40
	21	9.42 278	46	9.43 855	50	0.56 145	9.98 422	3	39
	22	9.42 324	46	9.43 905	49	0.56 095	9.98 419	4	38
	23	9.42 370	46	9.43 954	50	0.56 046	9.98 415	3	37
	24	9.42 416	45	9.44 004	49	0.55 996	9.98 412	3	36
	25	9.42 461	46	9.44 053	49	0.55 947	9.98 409	4	35
	26	9.42 507	46	9.44 102	49	0.55 898	9.98 405	3	34
	27	9.42 553	46	9.44 151	50	0.55 849	9.98 402	4	33
	28	9.42 599	45	9.44 201	49	0.55 799	9.98 398	3	32
	29	9.42 644	46	9.44 250	49	0.55 750	9.98 395	4	31
	30	9.42 690	45	9.44 298	49	0.55 701	9.98 391	3	30
	31	9.42 735	46	9.44 348	49	0.55 652	9.98 388	4	29
	32	9.42 781	45	9.44 397	49	0.55 603	9.98 384	3	28
	33	9.42 826	46	9.44 446	49	0.55 554	9.98 381	4	27
	34	9.42 872	45	9.44 495	49	0.55 505	9.98 377	4	26
	35	9.42 917	45	9.44 544	48	0.55 456	9.98 373	3	25
	36	9.42 962	46	9.44 592	49	0.55 408	9.98 370	4	24
	37	9.43 008	45	9.44 641	49	0.55 359	9.98 366	3	23
	38	9.43 053	45	9.44 690	48	0.55 310	9.98 363	4	22
	39	9.43 098	45	9.44 738	49	0.55 262	9.98 359	3	21
	40	9.43 143	45	9.44 787	49	0.55 213	9.98 356	4	20
	41	9.43 188	45	9.44 836	48	0.55 164	9.98 352	3	19
	42	9.43 233	45	9.44 884	49	0.55 116	9.98 349	4	18
	43	9.43 278	45	9.44 933	48	0.55 067	9.98 345	3	17
	44	9.43 323	44	9.44 981	48	0.55 019	9.98 342	4	16
	45	9.43 367	45	9.45 029	49	0.54 971	9.98 338	4	15
	46	9.43 412	45	9.45 078	48	0.54 922	9.98 334	3	14
	47	9.43 457	45	9.45 126	48	0.54 874	9.98 331	4	13
	48	9.43 502	44	9.45 174	48	0.54 826	9.98 327	3	12
	49	9.43 546	45	9.45 222	49	0.54 778	9.98 324	4	11
	50	9.43 591	44	9.45 271	48	0.54 729	9.98 320	3	10
	51	9.43 635	45	9.45 319	48	0.54 681	9.98 317	4	9
	52	9.43 680	44	9.45 367	48	0.54 633	9.98 313	4	8
	53	9.43 724	45	9.45 415	48	0.54 585	9.98 309	3	7
	54	9.43 769	44	9.45 463	48	0.54 537	9.98 306	4	6
	55	9.43 813	44	9.45 511	48	0.54 489	9.98 302	3	5
	56	9.43 857	44	9.45 559	47	0.54 441	9.98 299	4	4
	57	9.43 901	45	9.45 606	48	0.54 394	9.98 295	4	3
	58	9.43 946	44	9.45 654	48	0.54 346	9.98 291	3	2
	59	9.43 990	44	9.45 702	48	0.54 298	9.98 288	4	1
	60	9.44 034		9.45 750		0.54 250	9.98 284		0
		L SIN	D	L TAN	CD	L COT	L COS	D	344°...164°
		L COS		L COT		L TAN	L SIN		254°... 74°

16°...196°		L SIN	D	L TAN	CD	L COT	L COS	D	
106°...286°		L COS		L COT		L TAN	L SIN		
	0	9.44 034	44	9.45 750	47	0.54 250	9.98 284	3	60
	1	9.44 078		9.45 797		0.54 203	9.98 281		59
	2	9.44 122		9.45 845		0.54 155	9.98 277		58
	3	9.44 166		9.45 892		0.54 108	9.98 273		57
	4	9.44 210	43	9.45 940	47	0.54 060	9.98 270	4	56
	5	9.44 253	44	9.45 987	48	0.54 013	9.98 266	4	55
	6	9.44 297		9.46 035		0.53 965	9.98 262		54
	7	9.44 341		9.46 082		0.53 918	9.98 259		53
	8	9.44 385		9.46 130		0.53 870	9.98 255		52
	9	9.44 428	43	9.46 177	47	0.53 823	9.98 251	4	51
	10	9.44 472	44	9.46 224	47	0.53 776	9.98 248	3	50
	11	9.44 516		9.46 271		0.53 729	9.98 244		49
	12	9.44 559		9.46 319		0.53 681	9.98 240		48
	13	9.44 602		9.46 366		0.53 634	9.98 237		47
	14	9.44 646	43	9.46 413	47	0.53 587	9.98 233	4	46
	15	9.44 689	44	9.46 460	47	0.53 540	9.98 229	3	45
	16	9.44 733		9.46 507		0.53 493	9.98 226		44
	17	9.44 776		9.46 554		0.53 446	9.98 222		43
	18	9.44 819		9.46 601		0.53 399	9.98 218		42
	19	9.44 862	43	9.46 648	46	0.53 352	9.98 215	4	41
	20	9.44 905	43	9.46 694	47	0.53 306	9.98 211	4	40
	21	9.44 948		9.46 711		0.53 259	9.98 207		39
	22	9.44 992		9.46 788		0.53 212	9.98 204		38
	23	9.45 035		9.46 835		0.53 165	9.98 200		37
	24	9.45 077	42	9.46 861	46	0.53 119	9.98 196	4	36
	25	9.45 120	43	9.46 928	47	0.53 072	9.98 192	3	35
	26	9.45 163		9.46 975		0.53 025	9.98 189		34
	27	9.45 206		9.47 021		0.52 979	9.98 185		33
	28	9.45 249		9.47 068		0.52 932	9.98 181		32
	29	9.45 292	42	9.47 114	46	0.52 886	9.98 177	4	31
	30	9.45 334	43	9.47 160	47	0.52 840	9.98 174	4	30
	31	9.45 377		9.47 207		0.52 793	9.98 170		29
	32	9.45 419		9.47 253		0.52 747	9.98 166		28
	33	9.45 462		9.47 299		0.52 701	9.98 162		27
	34	9.45 504	42	9.47 346	47	0.52 654	9.98 159	3	26
	35	9.45 547	42	9.47 392	46	0.52 608	9.98 155	4	25
	36	9.45 589		9.47 438		0.52 562	9.98 151		24
	37	9.45 632		9.47 484		0.52 516	9.98 147		23
	38	9.45 674		9.47 530		0.52 470	9.98 144		22
	39	9.45 716	42	9.47 576	46	0.52 424	9.98 140	4	21
	40	9.45 758	43	9.47 622	46	0.52 378	9.98 136	4	20
	41	9.45 801		9.47 668		0.52 332	9.98 132		19
	42	9.45 843		9.47 714		0.52 286	9.98 129		18
	43	9.45 885		9.47 760		0.52 240	9.98 125		17
	44	9.45 927	42	9.47 806	46	0.52 194	9.98 121	4	16
	45	9.45 969	42	9.47 852	45	0.52 148	9.98 117	4	15
	46	9.46 011		9.47 897		0.52 103	9.98 113		14
	47	9.46 053		9.47 943		0.52 057	9.98 110		13
	48	9.46 095		9.47 989		0.52 011	9.98 106		12
	49	9.46 136	41	9.48 035	46	0.51 965	9.98 102	4	11
	50	9.46 178	42	9.48 080	46	0.51 920	9.98 098	4	10
	51	9.46 220		9.48 126		0.51 874	9.98 094		9
	52	9.46 262		9.48 171		0.51 829	9.98 090		8
	53	9.46 303		9.48 217		0.51 783	9.98 087		7
	54	9.46 345	41	9.48 262	45	0.51 738	9.98 083	4	6
	55	9.46 386	42	9.48 307	46	0.51 693	9.98 079	4	5
	56	9.46 428		9.48 353		0.51 647	9.98 075		4
	57	9.46 469		9.98 398		0.51 602	9.98 071		3
	58	9.46 511		9.48 443		0.51 557	9.98 067		2
	59	9.46 552	41	9.48 489	46	0.51 511	9.98 063	4	1
	60	9.46 594	42	9.48 534	45	0.51 466	9.98 060	3	0
		L SIN	D	L TAN	CD	L COT	L COS	D	343°...163°
		L COS		L COT		L TAN	L SIN		253°... 73°

17°...197°		L SIN	D	L TAN	CD	L COT	L COS	D	
107°...287°		L COS		L COT		L TAN	L SIN		
	0	9.46 594	41	9.48 534	45	0.51 466	9.98 060	4	60
	1	9.46 635		9.48 579		0.51 421	9.98 056		59
	2	9.46 676		9.48 624		0.51 376	9.98 052		58
	3	9.46 717		9.48 669		0.51 331	9.98 048		57
	4	9.46 758	42	9.48 714	45	0.51 286	9.98 044	4	56
	5	9.46 800		9.48 759		0.51 241	9.98 040		55
	6	9.46 841		9.48 804		0.51 196	9.98 036		54
	7	9.46 882		9.48 849		0.51 151	9.98 032		53
	8	9.46 923	41	9.48 894	45	0.51 106	9.98 029	3	52
	9	9.46 964		9.48 939		0.51 061	9.98 025		51
	10	9.47 005		9.48 984		0.51 016	9.98 021		50
	11	9.47 045	40	9.49 029	44	0.50 971	9.98 017	4	49
	12	9.47 086		9.49 073		0.50 927	9.98 013		48
	13	9.47 127		9.49 118		0.50 882	9.98 009		47
	14	9.47 168		9.49 163		0.50 837	9.98 005		46
	15	9.47 209	40	9.49 207	45	0.50 793	9.98 001	4	45
	16	9.47 249		9.49 252		0.50 748	9.97 997		44
	17	9.47 290		9.49 296		0.50 704	9.97 993		43
	18	9.47 330		9.49 341		0.50 659	9.97 989		42
	19	9.47 371	40	9.49 385	45	0.50 615	9.97 986	3	41
	20	9.47 411		9.49 430		0.50 570	9.97 982		40
	21	9.47 452		9.49 474		0.50 526	9.97 978		39
	22	9.47 492		9.49 519		0.50 481	9.97 974		38
	23	9.47 533	40	9.49 563	44	0.50 437	9.97 970	4	37
	24	9.47 573		9.49 607		0.50 393	9.97 966		36
	25	9.47 613		9.49 652		0.50 348	9.97 962		35
	26	9.47 654	40	9.49 696	44	0.50 304	9.97 958	4	34
	27	9.47 694		9.49 740		0.50 260	9.97 954		33
	28	9.47 734		9.49 784		0.50 216	9.97 950		32
	29	9.47 774		9.49 828		0.50 172	9.97 946		31
	30	9.47 814	40	9.49 872	44	0.50 128	9.97 942	4	30
	31	9.47 854		9.49 916		0.50 084	9.97 938		29
	32	9.47 894		9.49 960		0.50 040	9.97 934		28
	33	9.47 934		9.50 004		0.49 996	9.97 930		27
	34	9.47 974	40	9.50 048	44	0.49 952	9.97 926	4	26
	35	9.48 014		9.50 092		0.49 908	9.97 922		25
	36	9.48 054		9.50 136		0.49 864	9.97 918		24
	37	9.48 094		9.50 180		0.49 820	9.97 914		23
	38	9.48 133	39	9.50 223	43	0.49 777	9.97 910	4	22
	39	9.48 173		9.50 267		0.49 733	9.97 906		21
	40	9.48 213		9.50 311		0.49 689	9.97 902		20
	41	9.48 252		9.50 355		0.49 645	9.97 898		19
	42	9.48 292	40	9.50 398	43	0.49 602	9.97 894	4	18
	43	9.48 332		9.50 442		0.49 558	9.97 890		17
	44	9.48 371		9.50 485		0.49 515	9.97 886		16
	45	9.48 411		9.50 529	43	0.49 471	9.97 882	4	15
	46	9.48 450	39	9.50 572		0.49 428	9.97 878		14
	47	9.48 490		9.50 616		0.49 384	9.97 874		13
	48	9.48 529		9.50 659		0.49 341	9.97 870		12
	49	9.48 568	39	9.50 703	43	0.49 297	9.97 866	5	11
	50	9.48 607		9.50 746		0.49 254	9.97 861		10
	51	9.48 647		9.50 789		0.49 211	9.97 857		9
	52	9.48 686		9.50 833	43	0.49 167	9.97 853	4	8
	53	9.48 725	39	9.50 876		0.49 124	9.97 849		7
	54	9.48 764		9.50 919		0.49 081	9.97 845		6
	55	9.48 803		9.50 962		0.49 038	9.97 841		5
	56	9.48 842	39	9.51 005	43	0.48 995	9.97 837	4	4
	57	9.48 881		9.51 048		0.48 952	9.97 833		3
	58	9.48 920		9.51 092		0.48 908	9.97 829		2
	59	9.48 959		9.51 135		0.48 865	9.97 825		1
	60	9.48 998	39	9.51 178	43	0.48 822	9.97 821	4	0
		L SIN		L TAN		L COT	L COS		342°...162°
		L COS		L COT		L TAN	L SIN		252°... 72°

18°...198°		L SIN	D	L TAN	CD	L COT	L COS	D	
108°...288°		L COS		L COT		L TAN	L SIN		
	0	9.48 098		9.51 178		0.48 822	9.97 821		60
	1	9.49 037	39	9.51 221	43	0.48 779	9.97 817	4	59
	2	9.49 076	39	9.51 264	43	0.48 736	9.97 812	5	58
	3	9.49 115	39	9.51 306	42	0.48 694	9.97 808	4	57
	4	9.49 153	38	9.51 349	43	0.48 651	9.97 804	4	56
			39		43			4	
	5	9.49 192		9.51 392		0.48 608	9.97 800		55
	6	9.49 231	39	9.51 435	43	0.48 565	9.97 796	4	54
	7	9.49 269	38	9.51 478	43	0.48 522	9.97 792	4	53
	8	9.49 308	39	9.51 520	42	0.48 480	9.97 788	4	52
	9	9.49 347	39	9.51 563	43	0.48 437	9.97 784	4	51
			38		43			5	
	10	9.49 385		9.51 606		0.48 394	9.97 779		50
	11	9.49 424	39	9.51 648	42	0.48 352	9.97 775	4	49
	12	9.49 462	38	9.51 691	43	0.48 309	9.97 771	4	48
	13	9.49 500	38	9.51 734	43	0.48 266	9.97 767	4	47
	14	9.49 539	39	9.51 776	42	0.48 224	9.97 763	4	46
			38		43			4	
	15	9.49 577		9.51 819		0.48 181	9.97 759		45
	16	9.49 615	38	9.51 861	42	0.48 139	9.97 754	5	44
	17	9.49 654	39	9.51 903	42	0.48 097	9.97 750	4	43
	18	9.49 692	38	9.51 946	43	0.48 054	9.97 746	4	42
	19	9.49 730	38	9.51 988	42	0.48 012	9.97 742	4	41
			38		43			4	
	20	9.49 768		9.52 031		0.47 969	9.97 738		40
	21	9.49 806	38	9.52 073	42	0.47 927	9.97 734	4	39
	22	9.49 844	38	9.52 115	42	0.47 885	9.97 729	5	38
	23	9.49 882	38	9.52 157	42	0.47 843	9.97 725	4	37
	24	9.49 920	38	9.52 200	43	0.47 800	9.97 721	4	36
			38		42			4	
	25	9.49 958		9.52 242		0.47 758	9.97 717		35
	26	9.49 996	38	9.52 284	42	0.47 716	9.97 713	4	34
	27	9.50 034	38	9.52 326	42	0.47 674	9.97 708	5	33
	28	9.50 072	38	9.52 368	42	0.47 632	9.97 704	4	32
	29	9.50 110	38	9.52 410	42	0.47 590	9.97 700	4	31
			38		42			4	
	30	9.50 148		9.52 452		0.47 548	9.97 699		30
	31	9.50 185	37	9.52 494	42	0.47 506	9.97 691	5	29
	32	9.50 223	38	9.52 536	42	0.47 464	9.97 687	4	28
	33	9.50 261	38	9.52 578	42	0.47 422	9.97 683	4	27
	34	9.50 298	37	9.52 620	42	0.47 380	9.97 679	4	26
			38		41			5	
	35	9.50 336		9.52 661		0.47 339	9.97 674		25
	36	9.50 374	38	9.52 703	42	0.47 297	9.97 670	4	24
	37	9.50 411	37	9.52 745	42	0.47 255	9.97 666	4	23
	38	9.50 449	38	9.52 787	42	0.47 213	9.97 662	4	22
	39	9.50 486	37	9.52 829	42	0.47 171	9.97 657	5	21
			37		41			4	
	40	9.50 523		9.52 870		0.47 130	9.97 653		20
	41	9.50 561	38	9.52 912	42	0.47 088	9.97 649	4	19
	42	9.50 598	37	9.52 953	41	0.47 047	9.97 645	4	18
	43	9.50 635	37	9.52 995	42	0.47 005	9.97 640	5	17
	44	9.50 673	38	9.53 037	42	0.46 963	9.97 636	4	16
			37		41			4	
	45	9.50 710		9.53 078		0.46 922	9.97 632		15
	46	9.50 747	37	9.53 120	42	0.46 880	9.97 628	4	14
	47	9.50 784	37	9.53 161	41	0.46 839	9.97 623	5	13
	48	9.50 821	37	9.53 202	41	0.46 798	9.97 619	4	12
	49	9.50 858	37	9.53 244	42	0.46 756	9.97 615	4	11
			38		41			5	
	50	9.50 896		9.53 285		0.46 715	9.97 610		10
	51	9.50 933	37	9.53 327	42	0.46 673	9.97 606	4	9
	52	9.50 970	37	9.53 368	41	0.46 632	9.97 602	4	8
	53	9.51 007	37	9.53 409	41	0.46 591	9.97 597	5	7
	54	9.51 043	36	9.53 450	41	0.46 550	9.97 593	4	6
			37		42			4	
	55	9.51 080		9.53 492		0.46 508	9.97 589		5
	56	9.51 117	37	9.53 533	41	0.46 467	9.97 584	5	4
	57	9.51 154	37	9.53 574	41	0.46 426	9.97 580	4	3
	58	9.51 191	37	9.53 615	41	0.46 385	9.97 576	4	2
	59	9.51 227	36	9.53 656	41	0.46 344	9.97 571	5	1
			37		41			4	
	60	9.51 264		9.53 697		0.46 303	9.97 567		0
		L SIN	D	L TAN	CD	L COT	L COS	D	341°...161°
		L COS		L COT		L TAN	L SIN		
									251°... 71°

19°...199°		L SIN	D	L TAN	CD	L COT	L COS	D	
109°...289°		L COS		L COT		L TAN	L SIN		
	0	9.51 264	37	9.53 697	41	0.46 303	9.97 567	4	60
	1	9.51 301	37	9.53 738	41	0.46 262	9.97 563	5	59
	2	9.51 338	36	9.53 779	41	0.46 221	9.97 558	4	58
	3	9.51 374	37	9.53 820	41	0.46 180	9.97 554	4	57
	4	9.51 411	36	9.53 861	41	0.46 139	9.97 550	5	56
	5	9.51 447	37	9.53 902	41	0.46 098	9.97 545	4	55
	6	9.51 484	36	9.53 943	41	0.46 057	9.97 541	5	54
	7	9.51 520	37	9.53 984	41	0.46 016	9.97 536	4	53
	8	9.51 557	36	9.54 025	40	0.45 975	9.97 532	4	52
	9	9.51 593	36	9.54 065	41	0.45 935	9.97 528	5	51
	10	9.51 629	37	9.54 106	41	0.45 894	9.97 523	4	50
	11	9.51 666	36	9.54 147	40	0.45 853	9.97 519	4	49
	12	9.51 702	36	9.54 187	41	0.45 813	9.97 515	5	48
	13	9.51 738	36	9.54 228	41	0.45 772	9.97 510	4	47
	14	9.51 774	37	9.54 269	40	0.45 731	9.97 506	5	46
	15	9.51 811	36	9.54 309	41	0.45 691	9.97 501	4	45
	16	9.51 847	36	9.54 350	40	0.45 650	9.97 497	5	44
	17	9.51 883	36	9.54 390	41	0.45 610	9.97 492	4	43
	18	9.51 919	36	9.54 431	40	0.45 569	9.97 488	4	42
	19	9.51 955	36	9.54 471	41	0.45 529	9.97 484	5	41
	20	9.51 991	36	9.54 512	40	0.45 488	9.97 479	4	40
	21	9.52 027	36	9.54 552	41	0.45 448	9.97 475	5	39
	22	9.52 063	36	9.54 593	40	0.45 407	9.97 470	4	38
	23	9.52 099	36	9.54 633	40	0.45 367	9.97 466	5	37
	24	9.52 135	36	9.54 673	41	0.45 327	9.97 461	4	36
	25	9.52 171	36	9.54 714	40	0.45 286	9.97 457	4	35
	26	9.52 207	35	9.54 754	40	0.45 246	9.97 453	5	34
	27	9.52 242	36	9.54 794	41	0.45 206	9.97 448	4	33
	28	9.52 278	36	9.54 835	40	0.45 165	9.97 444	5	32
	29	9.52 314	36	9.54 875	40	0.45 125	9.97 439	4	31
	30	9.52 350	35	9.54 915	40	0.45 085	9.97 435	5	30
	31	9.52 385	36	9.54 955	40	0.45 045	9.97 430	4	29
	32	9.52 421	35	9.54 995	40	0.45 005	9.97 426	5	28
	33	9.52 456	36	9.55 035	40	0.44 965	9.97 421	4	27
	34	9.52 492	35	9.55 075	40	0.44 925	9.97 417	5	26
	35	9.52 527	36	9.55 115	40	0.44 885	9.97 412	4	25
	36	9.52 563	35	9.55 155	40	0.44 845	9.97 408	5	24
	37	9.52 598	36	9.55 195	40	0.44 805	9.97 403	4	23
	38	9.52 634	35	9.55 235	40	0.44 765	9.97 399	5	22
	39	9.52 669	36	9.55 275	40	0.44 725	9.97 394	4	21
	40	9.52 705	35	9.55 315	40	0.44 685	9.97 390	5	20
	41	9.52 740	35	9.55 355	40	0.44 645	9.97 385	4	19
	42	9.52 775	36	9.55 395	39	0.44 605	9.97 381	5	18
	43	9.52 811	35	9.55 434	40	0.44 566	9.97 376	4	17
	44	9.52 846	35	9.55 474	40	0.44 526	9.97 372	5	16
	45	9.52 881	35	9.55 514	40	0.44 486	9.97 367	4	15
	46	9.52 916	35	9.55 554	39	0.44 446	9.97 363	5	14
	47	9.52 951	35	9.55 593	40	0.44 407	9.97 358	4	13
	48	9.52 986	35	9.55 633	40	0.44 367	9.97 353	5	12
	49	9.53 021	35	9.55 673	39	0.44 327	9.97 349	4	11
	50	9.53 056	36	9.55 712	40	0.44 288	9.97 344	4	10
	51	9.53 092	34	9.55 752	39	0.44 248	9.97 340	5	9
	52	9.53 126	35	9.55 791	40	0.44 209	9.97 335	4	8
	53	9.53 161	35	9.55 831	39	0.44 169	9.97 331	5	7
	54	9.53 196	35	9.55 870	40	0.44 130	9.97 326	4	6
	55	9.53 231	35	9.55 910	39	0.44 090	9.97 322	5	5
	56	9.53 266	35	9.55 949	40	0.44 051	9.97 317	4	4
	57	9.53 301	35	9.55 989	39	0.44 011	9.97 312	5	3
	58	9.53 336	34	9.56 028	39	0.43 972	9.97 308	4	2
	59	9.53 370	35	9.56 067	40	0.43 933	9.97 303	5	1
	60	9.53 405		9.56 107		0.43 893	9.97 299	4	0
		L SIN	D	L TAN	CD	L COT	L COS	D	340°...160°
		L COS		L COT		L TAN	L SIN		250°... 70°

20° ...200°		L SIN	D	L TAN	CD	L COT	L COS	D	
110° ...290°		L COS		L COT		L TAN	L SIN		
	0	9.53 405		9.56 107		0.43 893	9.97 299		60
	1	9.53 440	35	9.56 146	39	0.43 854	9.97 294	5	59
	2	9.53 475	35	9.56 185	39	0.43 815	9.97 289	5	58
	3	9.53 509	34	9.56 224	39	0.43 776	9.97 285	4	57
	4	9.53 544	35	9.56 264	40	0.43 736	9.97 280	5	56
			34		39			4	
	5	9.53 578		9.56 303		0.43 697	9.97 276		55
	6	9.53 613	35	9.56 342	39	0.43 658	9.97 271	5	54
	7	9.53 647	34	9.56 381	39	0.43 619	9.97 266	5	53
	8	9.53 682	35	9.56 420	39	0.43 580	9.97 262	4	52
	9	9.53 716	34	9.56 459	39	0.43 541	9.97 257	5	51
			35		39			5	
	10	9.53 751		9.56 498		0.43 502	9.97 252		50
	11	9.53 785	34	9.56 537	39	0.43 463	9.97 248	4	49
	12	9.53 819	34	9.56 576	39	0.43 424	9.97 243	5	48
	13	9.53 854	35	9.56 615	39	0.43 385	9.97 238	5	47
	14	9.53 888	34	9.56 654	39	0.43 346	9.97 234	4	46
			34		39			5	
	15	9.53 922		9.56 693		0.43 307	9.97 229		45
	16	9.53 957	35	9.56 732	39	0.43 268	9.97 224	5	44
	17	9.53 991	34	9.56 771	39	0.43 229	9.97 220	4	43
	18	9.54 025	34	9.56 810	39	0.43 190	9.97 215	5	42
	19	9.54 059	34	9.56 849	39	0.43 151	9.97 210	5	41
			34		38			4	
	20	9.54 093		9.56 887		0.43 113	9.97 206		40
	21	9.54 127	34	9.56 926	39	0.43 074	9.97 201	5	39
	22	9.54 161	34	9.56 965	39	0.43 035	9.97 196	5	38
	23	9.54 195	34	9.57 004	39	0.42 996	9.97 192	4	37
	24	9.54 229	34	9.57 042	38	0.42 958	9.97 187	5	36
			34		39			5	
	25	9.54 263		9.57 081		0.42 919	9.97 182		35
	26	9.54 297	34	9.57 120	39	0.42 880	9.97 178	4	34
	27	9.54 331	34	9.57 158	38	0.42 842	9.97 173	5	33
	28	9.54 365	34	9.57 197	39	0.42 803	9.97 168	5	32
	29	9.54 399	34	9.57 235	38	0.42 765	9.97 163	5	31
			34		39			4	
	30	9.54 433		9.57 274		0.42 726	9.97 159		30
	31	9.54 466	33	9.57 312	38	0.42 688	9.97 154	5	29
	32	9.54 500	34	9.57 351	39	0.42 649	9.97 149	5	28
	33	9.54 534	34	9.57 389	38	0.42 611	9.97 145	4	27
	34	9.54 567	33	9.57 428	39	0.42 572	9.97 140	5	26
			34		38			5	
	35	9.54 601		9.57 466		0.42 534	9.97 135		25
	36	9.54 635	34	9.57 504	38	0.42 496	9.97 130	5	24
	37	9.54 668	33	9.57 543	39	0.42 457	9.97 126	4	23
	38	9.54 702	34	9.57 581	38	0.42 419	9.57 121	5	22
	39	9.54 735	33	9.57 619	38	0.42 381	9.57 116	5	21
			34		39			5	
	40	9.54 769		9.57 658		0.42 342	9.97 111		20
	41	9.54 802	33	9.57 696	38	0.42 304	9.97 107	4	19
	42	9.54 836	34	9.57 734	38	0.42 266	9.97 102	5	18
	43	9.54 869	33	9.57 772	38	0.42 228	9.97 097	5	17
	44	9.54 903	34	9.57 810	38	0.42 190	9.97 092	5	16
			33		39			5	
	45	9.54 936		9.57 849		0.42 151	9.97 087		15
	46	9.54 969	33	9.57 887	38	0.42 113	9.97 083	4	14
	47	9.55 003	34	9.57 925	38	0.42 075	9.97 078	5	13
	48	9.55 036	33	9.57 963	38	0.42 037	9.97 073	5	12
	49	9.55 069	33	9.58 001	38	0.41 999	9.97 068	5	11
			33		38			5	
	50	9.55 102		9.58 039		0.41 961	9.97 063		10
	51	9.55 136	34	9.58 077	38	0.41 923	9.97 059	4	9
	52	9.55 169	33	9.58 115	38	0.41 885	9.97 054	5	8
	53	9.55 202	33	9.58 153	38	0.41 847	9.97 049	5	7
	54	9.55 235	33	9.58 191	38	0.41 809	9.97 044	5	6
			33		38			5	
	55	9.55 268		9.58 229		0.41 771	9.97 039		5
	56	9.55 301	33	9.58 267	38	0.41 733	9.97 035	4	4
	57	9.55 334	33	9.58 304	37	0.41 696	9.97 030	5	3
	58	9.55 367	33	9.58 342	38	0.41 658	9.97 025	5	2
	59	9.55 400	33	9.58 380	38	0.41 620	9.97 020	5	1
			33		38			5	
	60	9.55 433		9.58 418		0.41 582	9.97 015		0
		L SIN	D	L TAN	CD	L COT	L COS	D	
		L COS		L COT		L TAN	L SIN		
									339° ...159°
									249° ... 69°

21°...201°		L SIN		L TAN		L COT	L COS		
111°...291°		L COS	D	L COT	CD	L TAN	L SIN	D	
	0	9.55 433	33	9.58 418	37	0.41 582	9.97 015	5	60
	1	9.55 466	33	9.58 455	38	0.41 545	9.97 010	5	59
	2	9.55 499	33	9.58 493	38	0.41 507	9.97 005	4	58
	3	9.55 532	32	9.58 531	38	0.41 469	9.97 001	5	57
	4	9.55 564	33	9.58 569	37	0.41 431	9.96 996	5	56
	5	9.55 597	33	9.58 606	38	0.41 394	9.96 991	5	55
	6	9.55 630	33	9.58 644	37	0.41 356	9.96 986	5	54
	7	9.55 663	32	9.58 681	38	0.41 319	9.96 981	5	53
	8	9.55 695	33	9.58 719	38	0.41 281	9.96 976	5	52
	9	9.55 728	33	9.58 757	37	0.41 243	9.96 971	5	51
	10	9.55 761	32	9.58 794	38	0.41 206	9.96 966	4	50
	11	9.55 793	33	9.58 832	37	0.41 168	9.96 962	5	49
	12	9.55 826	32	9.58 869	38	0.41 131	9.96 957	5	48
	13	9.55 858	33	9.58 907	37	0.41 093	9.96 952	5	47
	14	9.55 891	32	9.58 944	37	0.41 056	9.96 947	5	46
	15	9.55 923	33	9.58 981	38	0.41 019	9.96 942	5	45
	16	9.55 956	32	9.59 019	37	0.40 981	9.96 937	5	44
	17	9.55 988	33	9.59 056	38	0.40 944	9.96 932	5	43
	18	9.56 021	32	9.59 094	37	0.40 906	9.96 927	5	42
	19	9.56 053	32	9.59 131	37	0.40 869	9.96 922	5	41
	20	9.56 085	33	9.59 168	37	0.40 832	9.96 917	5	40
	21	9.56 118	32	9.59 205	38	0.40 795	9.96 912	5	39
	22	9.56 150	32	9.59 243	37	0.40 757	9.96 907	4	38
	23	9.56 182	33	9.59 280	37	0.40 720	9.96 903	5	37
	24	9.56 215	32	9.59 317	37	0.40 683	9.96 898	5	36
	25	9.56 247	32	9.59 354	37	0.40 646	9.96 893	5	35
	26	9.56 279	32	9.59 391	38	0.40 609	9.96 888	5	34
	27	9.56 311	32	9.59 429	37	0.40 571	9.96 883	5	33
	28	9.56 343	32	9.59 466	37	0.40 534	9.96 878	5	32
	29	9.56 375	33	9.59 503	37	0.40 497	9.96 873	5	31
	30	9.56 408	32	9.59 540	37	0.40 460	9.96 868	5	30
	31	9.56 440	32	9.59 577	37	0.40 423	9.96 863	5	29
	32	9.56 472	32	9.59 614	37	0.40 386	9.96 858	5	28
	33	9.56 504	32	9.59 651	37	0.40 349	9.96 853	5	27
	34	9.56 536	32	9.59 688	37	0.40 312	9.96 848	5	26
	35	9.56 568	31	9.59 725	37	0.40 275	9.96 843	5	25
	36	9.56 599	32	9.59 762	37	0.40 238	9.96 838	5	24
	37	9.96 631	32	9.59 799	36	0.40 201	9.96 833	5	23
	38	9.56 663	32	9.59 835	37	0.40 165	9.96 828	5	22
	39	9.56 695	32	9.59 872	37	0.40 128	9.96 823	5	21
	40	9.56 727	32	9.59 909	37	0.40 091	9.96 818	5	20
	41	9.56 759	31	9.59 946	37	0.40 054	9.96 813	5	19
	42	9.56 790	32	9.59 983	36	0.40 017	9.96 808	5	18
	43	9.56 822	32	9.60 019	37	0.39 981	9.96 803	5	17
	44	9.56 854	32	9.60 056	37	0.39 944	9.96 798	5	16
	45	9.56 886	31	9.60 093	37	0.39 907	9.96 793	5	15
	46	9.56 917	32	9.60 130	36	0.39 870	9.96 788	5	14
	47	9.56 949	31	9.60 166	37	0.39 834	9.96 783	5	13
	48	9.56 980	32	9.60 203	37	0.39 797	9.96 778	5	12
	49	9.57 012	32	9.60 240	36	0.39 760	9.96 772	5	11
	50	9.57 044	31	9.60 276	37	0.39 724	9.96 767	5	10
	51	9.57 075	32	9.60 313	36	0.39 687	9.96 762	5	9
	52	9.57 107	31	9.60 349	37	0.39 651	9.96 757	5	8
	53	9.57 133	31	9.60 386	36	0.39 614	9.96 752	5	7
	54	9.57 169	32	9.60 422	37	0.39 578	9.96 747	5	6
	55	9.57 201	31	9.60 459	36	0.39 541	9.96 742	5	5
	56	9.57 232	32	9.60 495	37	0.39 505	9.96 737	5	4
	57	9.57 264	31	9.60 532	36	0.39 468	9.96 732	5	3
	58	9.57 295	31	9.60 568	37	0.39 432	9.96 727	5	2
	59	9.57 326	32	9.60 605	36	0.39 395	9.96 722	5	1
	60	9.57 358		9.60 641		0.39 359	9.96 717		0
		L SIN	D	L TAN	CD	L COT	L COS	D	338°...158°
		L COS		L COT		L TAN	L SIN		248°... 68°

22°...202°		L SIN	D	L TAN	CD	L COT	L COS	D	
112°...292°		L COS		L COT		L TAN	L SIN		
	0	9.57 358	31	9.60 641	36	0.39 359	9.96 717	6	60
	1	9.57 389	31	9.60 677	37	0.39 323	9.96 711	5	59
	2	9.57 420	31	9.60 714	36	0.39 286	9.96 706	5	58
	3	9.57 451	31	9.60 750	36	0.39 250	9.96 701	5	57
	4	9.57 482	32	9.60 786	37	0.39 214	9.96 696	5	56
	5	9.57 514	31	9.60 823	36	0.39 177	9.96 691	5	55
	6	9.57 545	31	9.60 859	36	0.39 141	9.96 686	5	54
	7	9.57 576	31	9.60 895	36	0.39 105	9.96 681	5	53
	8	9.57 607	31	9.60 931	36	0.39 069	9.96 676	6	52
	9	9.57 638	31	9.60 967	37	0.39 033	9.96 670	5	51
	10	9.57 669	31	9.61 004	36	0.38 996	9.96 665	5	50
	11	9.57 700	31	9.61 040	36	0.38 960	9.96 660	5	49
	12	9.57 731	31	9.61 076	36	0.38 924	9.96 655	5	48
	13	9.57 762	31	9.61 112	36	0.38 888	9.96 650	5	47
	14	9.57 793	31	9.61 148	36	0.38 852	9.96 645	5	46
	15	9.57 824	31	9.61 184	36	0.38 816	9.96 640	6	45
	16	9.57 855	30	9.61 220	36	0.38 780	9.96 634	5	44
	17	9.57 885	31	9.61 256	36	0.38 744	9.96 629	5	43
	18	9.57 916	31	9.61 292	36	0.38 708	9.96 624	5	42
	19	9.57 947	31	9.61 328	36	0.38 672	9.96 619	5	41
	20	9.57 978	30	9.61 364	36	0.38 636	9.96 614	6	40
	21	9.58 008	31	9.61 400	36	0.38 600	9.96 608	5	39
	22	9.58 039	31	9.61 436	36	0.38 564	9.96 603	5	38
	23	9.58 070	31	9.61 472	36	0.38 528	9.96 598	5	37
	24	9.58 101	30	9.61 508	36	0.38 492	9.96 593	5	36
	25	9.58 131	31	9.61 544	35	0.38 456	9.96 588	6	35
	26	9.58 162	30	9.61 579	36	0.38 421	9.96 582	5	34
	27	9.58 192	31	9.61 615	36	0.38 385	9.96 577	5	33
	28	9.58 223	30	9.61 651	36	0.38 349	9.96 572	5	32
	29	9.58 253	31	9.61 687	35	0.38 313	9.96 567	5	31
	30	9.58 284	30	9.61 722	36	0.38 278	9.96 562	6	30
	31	9.58 314	31	9.61 758	36	0.38 242	9.96 556	5	29
	32	9.58 345	30	9.61 794	36	0.38 206	9.96 551	5	28
	33	9.58 375	31	9.61 830	35	0.38 170	9.96 546	5	27
	34	9.58 406	30	9.61 865	36	0.38 135	9.96 541	6	26
	35	9.58 436	31	9.61 901	35	0.38 099	9.96 535	5	25
	36	9.58 467	30	9.61 936	36	0.38 064	9.96 530	5	24
	37	9.58 497	30	9.61 972	36	0.38 028	9.96 525	5	23
	38	9.58 527	30	9.62 008	35	0.37 992	9.96 520	6	22
	39	9.58 557	31	9.62 043	36	0.37 957	9.96 514	5	21
	40	9.58 588	30	9.62 079	35	0.37 921	9.96 509	5	20
	41	9.58 618	30	9.62 114	36	0.37 886	9.96 504	6	19
	42	9.58 648	30	9.62 150	35	0.37 850	9.96 498	5	18
	43	9.58 678	31	9.62 185	36	0.37 815	9.96 493	5	17
	44	9.58 709	30	9.62 221	35	0.37 779	9.96 488	5	16
	45	9.58 739	30	9.62 256	36	0.37 744	9.96 483	6	15
	46	9.58 769	30	9.62 292	35	0.37 708	9.96 477	5	14
	47	9.58 799	30	9.62 327	35	0.37 673	9.96 472	5	13
	48	9.58 829	30	9.62 362	36	0.37 638	9.96 467	6	12
	49	9.58 859	30	9.62 398	35	0.37 602	9.96 461	5	11
	50	9.58 889	30	9.62 433	35	0.37 567	9.96 456	5	10
	51	9.58 919	30	9.62 468	36	0.37 532	9.96 451	6	9
	52	9.58 949	30	9.62 504	35	0.37 496	9.96 445	5	8
	53	9.58 979	30	9.62 539	35	0.37 461	9.96 440	5	7
	54	9.59 009	30	9.62 574	35	0.37 426	9.96 435	6	6
	55	9.59 039	30	9.62 609	36	0.37 391	9.96 429	5	5
	56	9.59 069	29	9.62 645	35	0.37 355	9.96 424	5	4
	57	9.59 098	30	9.62 680	35	0.37 320	9.96 419	6	3
	58	9.59 128	30	9.62 715	35	0.37 285	9.96 413	5	2
	59	9.59 158	30	9.62 750	35	0.37 250	9.96 408	5	1
	60	9.59 188		9.62 785		0.37 215	9.96 403		0
		L SIN	D	L TAN	CD	L COT	L COS	D	337°...157°
		L COS		L COT		L TAN	L SIN		247°... 67°

23°...203°		L SIN		L TAN		L COT	L COS		
113°...293°		L COS	D	L COT	CD	L TAN	L SIN	D	
	0	9.59 188		9.62 785		0.37 215	9.96 403		60
	1	9.59 218	30	9.62 820	35	0.37 180	9.96 397	6	59
	2	9.59 247	29	9.62 855	35	0.37 145	9.96 392	5	58
	3	9.59 277	30	9.62 890	35	0.37 110	9.96 387	5	57
	4	9.59 307	30	9.62 926	36	0.37 074	9.96 381	6	56
			29		35			5	
	5	9.59 336		9.62 961		0.37 039	9.96 376		55
	6	9.59 366	30	9.62 996	35	0.37 004	9.96 370	6	54
	7	9.59 396	30	9.63 031	35	0.36 969	9.96 365	5	53
	8	9.59 425	29	9.63 066	35	0.36 934	9.96 360	5	52
	9	9.59 455	30	9.63 101	35	0.36 899	9.96 354	6	51
			29		34			5	
	10	9.59 484		9.63 135		0.36 865	9.96 349		50
	11	9.59 514	30	9.63 170	35	0.36 830	9.96 343	6	49
	12	9.59 543	29	9.63 205	35	0.36 795	9.96 338	5	48
	13	9.59 573	30	9.63 240	35	0.36 760	9.96 333	5	47
	14	9.59 602	29	9.63 275	35	0.36 725	9.96 327	6	46
			30		35			5	
	15	9.59 632		9.63 310		0.36 690	9.96 322		45
	16	9.59 661	29	9.63 345	35	0.36 655	9.96 316	6	44
	17	9.59 690	29	9.63 379	34	0.36 621	9.96 311	5	43
	18	9.59 720	30	9.63 414	35	0.36 586	9.96 305	6	42
	19	9.59 749	29	9.63 449	35	0.36 551	9.96 300	5	41
			29		35			6	
	20	9.59 778		9.63 484		0.36 516	9.96 294		40
	21	9.59 808	30	9.63 519	35	0.36 481	9.96 289	5	39
	22	9.59 837	29	9.63 553	34	0.36 447	9.96 284	5	38
	23	9.59 866	29	9.63 588	35	0.36 412	9.96 278	6	37
	24	9.59 895	29	9.63 623	35	0.36 377	9.96 273	5	36
			29		34			6	
	25	9.59 924		9.63 657		0.36 343	9.96 267		35
	26	9.59 954	30	9.63 692	35	0.36 308	9.96 262	5	34
	27	9.59 983	29	9.63 726	34	0.36 274	9.96 256	6	33
	28	9.60 012	29	9.63 761	35	0.36 239	9.96 251	5	32
	29	9.60 041	29	9.63 796	35	0.36 204	9.96 245	6	31
			29		34			5	
	30	9.60 070		9.63 830		0.36 170	9.96 240		30
	31	9.60 099	29	9.63 865	35	0.36 135	9.96 234	6	29
	32	9.60 128	29	9.63 899	34	0.36 101	9.96 229	5	28
	33	9.60 157	29	9.63 934	35	0.36 066	9.96 223	6	27
	34	9.60 186	29	9.63 968	34	0.36 032	9.96 218	5	26
			29		35			6	
	35	9.60 215		9.64 003		0.35 997	9.96 212		25
	36	9.60 244	29	9.64 037	34	0.35 963	9.96 207	5	24
	37	9.60 273	29	9.64 072	35	0.35 928	9.96 201	6	23
	38	9.60 302	29	9.64 106	34	0.35 894	9.96 196	5	22
	39	9.60 331	29	9.64 140	34	0.35 860	9.96 190	6	21
			28		35			5	
	40	9.60 359		9.64 175		0.35 825	9.96 185		20
	41	9.60 388	29	9.64 209	34	0.35 791	9.96 179	6	19
	42	9.60 417	29	9.64 243	34	0.35 757	9.96 174	5	18
	43	9.60 446	29	9.64 278	35	0.35 722	9.96 168	6	17
	44	9.60 474	28	9.64 312	34	0.35 688	9.96 162	6	16
			29		34			5	
	45	9.60 503		9.64 346		0.35 654	9.96 157		15
	46	9.60 532	29	9.64 381	35	0.35 619	9.96 151	6	14
	47	9.60 561	29	9.64 415	34	0.35 585	9.96 146	5	13
	48	9.60 589	28	9.64 449	34	0.35 551	9.96 140	6	12
	49	9.60 618	29	9.64 483	34	0.35 517	9.96 135	5	11
			28		34			6	
	50	9.60 646		9.64 517		0.35 483	9.96 129		10
	51	9.60 675	29	9.64 552	35	0.35 448	9.96 123	6	9
	52	9.60 704	29	9.64 586	34	0.35 414	9.96 118	5	8
	53	9.60 732	28	9.64 620	34	0.35 380	9.96 112	6	7
	54	9.60 761	29	9.64 654	34	0.35 346	9.96 107	5	6
			28		34			6	
	55	9.60 789		9.64 688		0.35 312	9.96 101		5
	56	9.60 818	29	9.64 722	34	0.35 278	9.96 095	6	4
	57	9.60 846	28	9.64 756	34	0.35 244	9.96 090	5	3
	58	9.60 875	29	9.64 790	34	0.35 210	9.96 084	6	2
	59	9.60 903	28	9.64 824	34	0.35 176	9.96 079	5	1
			28		34			6	
	60	9.60 931		9.64 858		0.35 142	9.96 073		0
		L SIN		L TAN		L COT	L COS		336°...156°
		L COS	D	L COT	CD	L TAN	L SIN	D	246°... 66°

24°...204°		L SIN	D	L TAN	CD	L COT	L COS	D	
114°...294°		L COS		L COT		L TAN	L SIN		
	0	9.60 931		9.64 858		0.35 142	9.96 073		60
	1	9.60 960	29	9.64 892	34	0.35 108	9.96 067	6	59
	2	9.60 988	28	9.64 926	34	0.35 074	9.96 062	5	58
	3	9.61 016	28	9.64 960	34	0.35 040	9.96 056	6	57
	4	9.61 045	29	9.64 994	34	0.35 006	9.95 050	6	56
			28		34			5	
	5	9.61 073		9.65 028		0.34 972	9.96 045		55
	6	9.61 101	28	9.65 062	34	0.34 938	9.96 039	6	54
	7	9.61 129	28	9.65 096	34	0.34 904	9.96 034	5	53
	8	9.61 158	29	9.65 130	34	0.34 870	9.96 028	6	52
	9	9.61 186	28	9.65 164	34	0.34 836	9.96 022	6	51
			28		33			5	
	10	9.61 214		9.65 197		0.34 803	9.96 017		50
	11	9.61 242	28	9.65 231	34	0.34 769	9.96 011	6	49
	12	9.61 270	28	9.65 265	34	0.34 735	9.96 005	6	48
	13	9.61 298	28	9.65 299	34	0.34 701	9.96 000	5	47
	14	9.61 326	28	9.65 333	34	0.34 667	9.95 994	6	46
			28		33			6	
	15	9.61 354		9.65 366		0.34 634	9.95 988		45
	16	9.61 382	28	9.65 400	34	0.34 600	9.95 982	6	44
	17	9.61 411	29	9.65 434	34	0.34 566	9.95 977	5	43
	18	9.61 438	27	9.65 467	33	0.34 533	9.95 971	6	42
	19	9.61 466	28	9.65 501	34	0.34 499	9.95 965	6	41
			28		34			5	
	20	9.61 494		9.65 535		0.34 465	9.95 960		40
	21	9.61 522	28	9.65 568	33	0.34 432	9.95 954	6	39
	22	9.61 550	28	9.65 602	34	0.34 398	9.95 948	6	38
	23	9.61 578	28	9.65 636	34	0.34 364	9.95 942	6	37
	24	9.61 606	28	9.65 669	33	0.34 331	9.95 937	5	36
			28		34			6	
	25	9.61 634		9.65 703		0.34 297	9.95 931		35
	26	9.61 662	28	9.65 736	33	0.34 264	9.95 925	6	34
	27	9.61 689	27	9.65 770	34	0.34 230	9.95 920	5	33
	28	9.61 717	28	9.65 803	33	0.34 197	9.95 914	6	32
	29	9.61 745	28	9.65 837	34	0.34 163	9.95 908	6	31
			28		33			6	
	30	9.61 773		9.65 870		0.34 130	9.95 902		30
	31	9.61 800	27	9.65 904	34	0.34 096	9.95 897	5	29
	32	9.61 828	28	9.65 937	33	0.34 063	9.95 891	6	28
	33	9.61 856	28	9.65 971	34	0.34 029	9.95 885	6	27
	34	9.61 883	27	9.66 004	33	0.33 996	9.95 879	6	26
			28		34			6	
	35	9.61 911		9.66 038		0.33 962	9.95 873		25
	36	9.61 939	28	9.66 071	33	0.33 929	9.95 868	5	24
	37	9.61 966	27	9.66 104	33	0.33 896	9.95 862	6	23
	38	9.61 994	28	9.66 138	34	0.33 862	9.95 856	6	22
	39	9.62 021	27	9.66 171	33	0.33 829	9.95 850	6	21
			28		33			6	
	40	9.62 049		9.66 204		0.33 796	9.95 844		20
	41	9.62 076	27	9.66 238	34	0.33 762	9.95 839	5	19
	42	9.62 104	28	9.66 271	33	0.33 729	9.95 833	6	18
	43	9.62 131	27	9.66 304	33	0.33 696	9.95 827	6	17
	44	9.62 159	28	9.66 337	33	0.33 663	9.95 821	6	16
			27		34			6	
	45	9.62 186		9.66 371		0.33 629	9.95 815		15
	46	9.62 214	28	9.66 404	33	0.33 596	9.95 810	5	14
	47	9.62 241	27	9.66 437	33	0.33 563	9.95 804	6	13
	48	9.62 268	27	9.66 470	33	0.33 530	9.95 798	6	12
	49	9.62 296	28	9.66 503	33	0.33 497	9.95 792	6	11
			27		34			6	
	50	9.62 323		9.66 527		0.33 463	9.95 786		10
	51	9.62 350	27	9.66 570	33	0.33 430	9.95 780	6	9
	52	9.62 377	27	9.66 603	33	0.33 397	9.95 775	5	8
	53	9.62 405	28	9.66 636	33	0.33 364	9.95 769	6	7
	54	9.62 432	27	9.66 669	33	0.33 331	9.95 763	6	6
			27		33			6	
	55	9.62 459		9.66 702		0.33 298	9.95 757		5
	56	9.62 486	27	9.66 735	33	0.33 265	9.95 751	6	4
	57	9.62 513	27	9.66 768	33	0.33 232	9.95 745	6	3
	58	9.62 541	28	9.66 801	33	0.33 199	9.95 739	6	2
	59	9.62 568	27	9.66 834	33	0.33 166	9.95 733	6	1
			27		33			5	
	60	9.62 595		9.66 867		0.33 133	9.95 728		0
		L SIN	D	L TAN	CD	L COT	L COS	D	
		L COS		L COT		L TAN	L SIN		
									335°...155°
									245°... 65°

25°...205°		L SIN	D	L TAN	CD	L COT	L COS	D	
115°...295°		L COS		L COT		L TAN	L SIN		
	0	9.62 595		9.66 867		0.33 133	9.95 728		60
	1	9.62 622	27	9.66 900	33	0.33 100	9.95 722	6	59
	2	9.62 649	27	9.66 933	33	0.33 067	9.95 716	6	58
	3	9.62 676	27	9.66 966	33	0.33 034	9.95 710	6	57
	4	9.62 703	27	9.66 999	33	0.33 001	9.95 704	6	56
			27		33			6	
	5	9.62 730		9.67 032		0.32 968	9.95 698		55
	6	9.62 757	27	9.67 065	33	0.32 935	9.95 692	6	54
	7	9.62 784	27	9.67 098	33	0.32 902	9.95 686	6	53
	8	9.62 811	27	9.67 131	33	0.32 869	9.95 680	6	52
	9	9.62 838	27	9.67 163	32	0.32 837	9.95 674	6	51
			27		33			6	
	10	9.62 865		9.67 196		0.32 804	9.95 668		50
	11	9.62 892	27	9.67 229	33	0.32 771	9.95 663	5	49
	12	9.62 918	26	9.67 262	33	0.32 738	9.95 657	6	48
	13	9.62 945	27	9.67 295	33	0.32 705	9.95 651	6	47
	14	9.62 972	27	9.67 327	32	0.32 673	9.95 645	6	46
			27		33			6	
	15	9.62 999		9.67 360		0.32 640	9.95 639		45
	16	9.63 026	27	9.67 393	33	0.32 607	9.95 633	6	44
	17	9.63 052	26	9.67 426	33	0.32 574	9.95 627	6	43
	18	9.63 079	27	9.67 458	32	0.32 542	9.95 621	6	42
	19	9.63 106	27	9.67 491	33	0.32 509	9.95 615	6	41
			27		33			6	
	20	9.63 133		9.67 524		0.32 476	9.95 609		40
	21	9.63 159	26	9.67 556	32	0.32 444	9.95 603	6	39
	22	9.63 186	27	9.67 589	33	0.32 411	9.95 597	6	38
	23	9.63 213	27	9.67 622	33	0.32 378	9.95 591	6	37
	24	9.63 239	26	9.67 654	32	0.32 346	9.95 585	6	36
			27		33			6	
	25	9.63 266		9.67 687		0.32 313	9.95 579		35
	26	9.63 292	26	9.67 719	32	0.32 281	9.95 573	6	34
	27	9.63 319	27	9.67 752	33	0.32 248	9.95 567	6	33
	28	9.63 345	26	9.67 785	33	0.32 215	9.95 561	6	32
	29	9.63 372	27	9.67 817	32	0.32 183	9.95 555	6	31
			26		33			6	
	30	9.63 398		9.67 850		0.32 150	9.95 549		30
	31	9.63 425	27	9.67 882	32	0.32 118	9.95 543	6	29
	32	9.63 451	26	9.67 915	33	0.32 085	9.95 537	6	28
	33	9.63 478	27	9.67 947	32	0.32 053	9.95 531	6	27
	34	9.63 504	26	9.67 980	33	0.32 020	9.95 525	6	26
			27		32			6	
	35	9.63 531		9.68 012		0.31 988	9.95 519		25
	36	9.63 557	26	9.68 044	32	0.31 956	9.95 513	6	24
	37	9.63 583	26	9.68 077	33	0.31 923	9.95 507	6	23
	38	9.63 610	27	9.68 109	32	0.31 891	9.95 500	7	22
	39	9.63 636	26	9.68 142	33	0.31 858	9.95 494	6	21
			26		32			6	
	40	9.63 662		9.68 174		0.31 826	9.95 488		20
	41	9.63 689	27	9.68 206	32	0.31 794	9.95 482	6	19
	42	9.63 715	26	9.68 239	33	0.31 761	9.95 476	6	18
	43	9.63 741	26	9.68 271	32	0.31 729	9.95 470	6	17
	44	9.63 767	26	9.68 303	32	0.31 697	9.95 464	6	16
			27		33			6	
	45	9.63 794		9.68 336		0.31 664	9.95 458		15
	46	9.63 820	26	9.68 368	32	0.31 632	9.95 452	6	14
	47	9.63 846	26	9.68 400	32	0.31 600	9.95 446	6	13
	48	9.63 872	26	9.68 432	32	0.31 568	9.95 440	6	12
	49	9.63 898	26	9.68 465	33	0.31 535	9.95 434	6	11
			26		32			7	
	50	9.63 924		9.68 497		0.31 503	9.95 427		10
	51	9.63 950	26	9.68 529	32	0.31 471	9.95 421	6	9
	52	9.63 976	26	9.68 561	32	0.31 439	9.95 415	6	8
	53	9.64 002	26	9.68 593	32	0.31 407	9.95 409	6	7
	54	9.64 028	26	9.68 626	33	0.31 374	9.95 403	6	6
			26		32			6	
	55	9.64 054		9.68 658		0.31 342	9.95 397		5
	56	9.64 080	26	9.68 690	32	0.31 310	9.95 391	6	4
	57	9.64 106	26	9.68 722	32	0.31 278	9.95 384	7	3
	58	9.64 132	26	9.68 754	32	0.31 246	9.95 378	6	2
	59	9.64 158	26	9.68 786	32	0.31 214	9.95 372	6	1
			26		32			6	
	60	9.64 184		9.68 818		0.31 182	9.95 366		0
		L SIN	D	L TAN	CD	L COT	L COS	D	334°...154°
		L COS		L COT		L TAN	L SIN		244°...64°

26°...206°		L SIN	D	L TAN	CD	L COT	L COS	D	
116°...296°		L COS		L COT		L TAN	L SIN		
	0	9.64 184	26	9.68 818	32	0.31 182	9.95 366	6	60
	1	9.64 210	26	9.68 850	32	0.31 150	9.95 360	6	59
	2	9.64 236	26	9.68 882	32	0.31 118	9.95 354	6	58
	3	9.64 262	26	9.68 914	32	0.31 086	9.95 348	7	57
	4	9.64 288	25	9.68 946	32	0.31 054	9.95 341	6	56
	5	9.64 313	26	9.68 978	32	0.31 022	9.95 335	6	55
	6	9.64 339	26	9.69 010	32	0.30 990	9.95 329	6	54
	7	9.64 365	26	9.69 042	32	0.30 958	9.95 323	6	53
	8	9.64 391	26	9.69 074	32	0.30 926	9.95 317	7	52
	9	9.64 417	25	9.69 106	32	0.30 894	9.95 310	6	51
	10	9.64 442	26	9.69 138	32	0.30 862	9.95 304	6	50
	11	9.64 468	26	9.69 170	32	0.30 830	9.95 298	6	49
	12	9.64 494	25	9.69 202	32	0.30 798	9.95 292	6	48
	13	9.64 519	26	9.69 234	32	0.30 766	9.95 286	7	47
	14	9.64 545	26	9.69 266	32	0.30 734	9.95 279	6	46
	15	9.64 571	25	9.69 298	31	0.30 702	9.95 273	6	45
	16	9.64 596	26	9.69 329	32	0.30 671	9.95 267	6	45
	17	9.64 622	25	9.69 361	32	0.30 639	9.95 261	7	43
	18	9.64 647	26	9.69 393	32	0.30 607	9.95 254	6	42
	19	9.64 673	25	9.69 425	32	0.30 575	9.95 248	6	41
	20	9.64 698	26	9.69 457	31	0.30 543	9.95 242	6	40
	21	9.64 724	25	9.69 488	32	0.30 512	9.95 236	7	39
	22	9.64 749	26	9.69 520	32	0.30 480	9.95 229	6	38
	23	9.64 775	25	9.69 552	32	0.30 448	9.95 223	6	37
	24	9.64 800	26	9.69 584	31	0.30 416	9.95 217	6	36
	25	9.64 826	25	9.69 615	32	0.30 385	9.95 211	7	35
	26	9.64 851	26	9.69 647	32	0.30 353	9.95 204	6	34
	27	9.64 877	25	9.69 679	31	0.30 321	9.95 198	6	33
	28	9.64 902	25	9.69 710	32	0.30 290	9.95 192	7	32
	29	9.64 927	26	9.69 742	32	0.30 258	9.95 185	6	31
	30	9.64 953	25	9.69 774	31	0.30 226	9.95 179	6	30
	31	9.64 978	25	9.69 805	32	0.30 195	9.95 173	6	29
	32	9.65 003	26	9.69 837	31	0.30 163	9.95 167	7	28
	33	9.65 029	25	9.69 868	32	0.30 132	9.95 160	6	27
	34	9.65 054	25	9.69 900	32	0.30 100	9.95 154	6	26
	35	9.65 079	25	9.69 932	31	0.30 068	9.95 148	7	25
	36	9.65 104	26	9.69 963	32	0.30 037	9.95 141	6	24
	37	9.65 130	25	9.69 995	31	0.30 005	9.95 135	6	23
	38	9.65 155	25	9.70 026	32	0.29 974	9.95 129	7	22
	39	9.65 180	25	9.70 058	31	0.29 942	9.95 122	6	21
	40	9.65 205	25	9.70 089	32	0.29 911	9.95 116	6	20
	41	9.65 230	25	9.70 121	31	0.29 879	9.95 110	7	19
	42	9.65 255	26	9.70 152	32	0.29 848	9.95 103	6	18
	43	9.65 281	25	9.70 184	31	0.29 816	9.95 097	7	17
	44	9.65 306	25	9.70 215	32	0.29 785	9.95 090	6	16
	45	9.65 331	25	9.70 247	31	0.29 753	9.95 084	6	15
	46	9.65 356	25	9.70 278	31	0.29 722	9.95 078	7	14
	47	9.65 381	25	9.70 309	32	0.29 691	9.95 071	6	13
	48	9.65 406	25	9.70 341	31	0.29 659	9.95 065	6	12
	49	9.65 431	25	9.70 372	32	0.29 628	9.95 059	7	11
	50	9.65 456	25	9.70 404	31	0.29 596	9.95 052	6	10
	51	9.65 481	25	9.70 435	31	0.29 565	9.95 046	7	9
	52	9.65 506	25	9.70 466	32	0.29 534	9.95 039	6	8
	53	9.65 531	25	9.70 498	31	0.29 502	9.95 033	6	7
	54	9.65 556	24	9.70 529	31	0.29 471	9.95 027	7	6
	55	9.65 580	25	9.70 560	32	0.29 440	9.95 020	6	5
	56	9.65 605	25	9.70 592	31	0.29 408	9.95 014	7	4
	57	9.65 630	25	9.70 623	31	0.29 377	9.95 007	6	3
	58	9.65 655	25	9.70 654	31	0.29 346	9.95 001	6	2
	59	9.65 680	25	9.70 685	32	0.29 315	9.94 995	7	1
	60	9.65 705		9.70 717		0.29 283	9.94 988		0
		L SIN	D	L TAN	CD	L COT	L COS	D	333°...153°
		L COS		L COT		L TAN	L SIN		243°... 63°

27° ...207°		L SIN	D	L TAN	CD	L COT	L COS	D	
117° ...297°		L COS		L COT		L TAN	L SIN		
	0	9.65 705		9.70 717		0.29 283	9.94 988		60
	1	9.65 729	24	9.70 748	31	0.29 252	9.94 982	6	59
	2	9.65 754	25	9.70 779	31	0.29 221	9.94 975	7	58
	3	9.65 779	25	9.70 810	31	0.29 190	9.94 969	6	57
	4	9.65 804	25	9.70 841	31	0.29 159	9.94 962	7	56
			24		32			6	
	5	9.65 828		9.70 873		0.29 127	9.94 956		55
	6	9.65 853	25	9.70 904	31	0.29 096	9.94 949	7	54
	7	9.65 878	25	9.70 935	31	0.29 065	9.94 943	6	53
	8	9.65 902	24	9.70 966	31	0.29 034	9.94 936	7	52
	9	9.65 927	25	9.70 997	31	0.29 003	9.94 930	6	51
			25		31			7	
	10	9.65 962		9.71 028		0.28 972	9.94 923		50
	11	9.65 976	24	9.71 059	31	0.28 941	9.94 917	6	49
	12	9.66 001	25	9.71 090	31	0.28 910	9.94 911	6	48
	13	9.66 025	24	9.71 121	31	0.28 879	9.94 904	7	47
	14	9.66 050	25	9.71 153	32	0.28 847	9.94 898	6	46
			25		31			7	
	15	9.66 075		9.71 184		0.28 816	9.94 891		45
	16	9.66 099	24	9.71 215	31	0.28 785	9.94 885	6	44
	17	9.66 124	25	9.71 246	31	0.28 754	9.94 878	7	43
	18	9.66 148	24	9.71 277	31	0.28 723	9.94 871	7	42
	19	9.66 173	25	9.71 308	31	0.28 692	9.94 865	6	41
			24		31			7	
	20	9.66 197		9.71 339		0.28 661	9.94 858		40
	21	9.66 221	24	9.71 370	31	0.28 630	9.94 852	6	39
	22	9.66 246	25	9.71 401	31	0.28 599	9.94 845	7	38
	23	9.66 270	24	9.71 431	30	0.28 569	9.94 839	6	37
	24	9.66 295	25	9.71 462	31	0.28 538	9.94 832	7	36
			24		31			6	
	25	9.66 319		9.71 493		0.28 507	9.94 826		35
	26	9.66 343	24	9.71 524	31	0.28 476	9.94 819	7	34
	27	9.66 368	25	9.71 555	31	0.28 445	9.94 813	6	33
	28	9.66 392	24	9.71 586	31	0.28 414	9.94 806	7	32
	29	9.66 416	24	9.71 617	31	0.28 383	9.94 799	7	31
			25		31			6	
	30	9.66 441		9.71 648		0.28 352	9.94 793		30
	31	9.66 465	24	9.71 679	31	0.28 321	9.94 786	7	29
	32	9.66 489	24	9.71 709	30	0.28 291	9.94 780	6	28
	33	9.66 513	24	9.71 740	31	0.28 260	9.94 773	7	27
	34	9.66 537	24	9.71 771	31	0.28 229	9.94 767	6	26
			25		31			7	
	35	9.66 562		9.71 802		0.28 198	9.94 760		25
	36	9.66 586	24	9.71 833	31	0.28 167	9.94 753	7	24
	37	9.66 610	24	9.71 863	30	0.28 137	9.94 747	6	23
	38	9.66 634	24	9.71 894	31	0.28 106	9.94 740	7	22
	39	9.66 658	24	9.71 925	31	0.28 075	9.94 734	6	21
			24		30			7	
	40	9.66 682		9.71 955		0.28 045	9.94 727		20
	41	9.66 706	24	9.71 986	31	0.28 014	9.94 720	7	19
	42	9.66 731	25	9.72 017	31	0.27 983	9.94 714	6	18
	43	9.66 755	24	9.72 048	31	0.27 952	9.94 707	7	17
	44	9.66 779	24	9.72 078	30	0.27 922	9.94 700	7	16
			24		31			6	
	45	9.66 803		9.72 109		0.27 891	9.94 694		15
	46	9.66 827	24	9.72 140	31	0.27 860	9.94 687	7	14
	47	9.66 851	24	9.72 170	30	0.27 830	9.94 680	7	13
	48	9.66 875	24	9.72 201	31	0.27 799	9.94 674	6	12
	49	9.66 899	24	9.72 231	30	0.27 769	9.94 667	7	11
			23		31			7	
	50	9.66 922		9.72 262		0.27 738	9.94 660		10
	51	9.66 946	24	9.72 293	31	0.27 707	9.94 654	6	9
	52	9.66 970	24	9.72 323	30	0.27 677	9.94 647	7	8
	53	9.66 994	24	9.72 354	31	0.27 646	9.94 640	7	7
	54	9.67 018	24	9.72 384	30	0.27 616	9.94 634	6	6
			24		31			7	
	55	9.67 042		9.72 415		0.27 585	9.94 627		5
	56	9.67 066	24	9.72 445	30	0.27 555	9.94 620	7	4
	57	9.67 090	24	9.72 476	31	0.27 524	9.94 614	6	3
	58	9.67 113	23	9.72 506	30	0.27 494	9.94 607	7	2
	59	9.67 137	24	9.72 537	31	0.27 463	9.94 600	7	1
			24		30			7	
	60	9.67 161		9.72 567		0.27 433	9.94 593		0
		L SIN	D	L TAN	CD	L COT	L COS	D	332° ...152°
		L COS		L COT		L TAN	L SIN		242° ... 62°

28°...208°		L SIN	D	L TAN	CD	L COT	L COS	D	
118°...298°		L COS		L COT		L TAN	L SIN		
	0	9.67 161		9.72 567		0.27 433	9.94 593		60
	1	9.67 185	24	9.72 598	31	0.27 402	9.94 587	6	59
	2	9.67 208	23	9.72 628	30	0.27 372	9.94 580	7	58
	3	9.67 232	24	9.72 659	31	0.27 341	9.94 573	7	57
	4	9.67 256	24	9.72 689	30	0.27 311	9.94 567	6	56
			24		31			7	
	5	9.67 280		9.72 720		0.27 280	9.94 560		55
	6	9.67 303	23	9.72 750	30	0.27 250	9.94 553	7	54
	7	9.67 327	24	9.72 780	30	0.27 220	9.94 546	7	53
	8	9.67 350	23	9.72 811	31	0.27 189	9.94 540	6	52
	9	9.67 374	24	9.72 841	30	0.27 159	9.94 533	7	51
			24		31			7	
	10	9.67 398		9.72 872		0.27 128	9.94 526		50
	11	9.67 421	23	9.72 902	30	0.27 098	9.94 519	7	49
	12	9.67 445	24	9.72 932	30	0.27 068	9.94 513	6	48
	13	9.67 468	23	9.72 963	31	0.27 037	9.94 506	7	47
	14	9.67 492	24	9.72 993	30	0.27 007	9.94 499	7	46
			23		30			7	
	15	9.67 515		9.73 023		0.26 977	9.94 492		45
	16	9.67 539	24	9.73 054	31	0.26 946	9.94 485	7	44
	17	9.67 562	23	9.73 084	30	0.26 916	9.94 479	6	43
	18	9.67 586	24	9.73 114	30	0.26 886	9.94 472	7	42
	19	9.67 609	23	9.73 144	30	0.26 856	9.94 465	7	41
			24		31			7	
	20	9.67 633		9.73 175		0.26 825	9.94 458		40
	21	9.67 656	23	9.73 205	30	0.26 795	9.94 451	7	39
	22	9.67 680	24	9.73 235	30	0.26 765	9.94 445	6	38
	23	9.67 703	23	9.73 265	30	0.26 735	9.94 438	7	37
	24	9.67 726	23	9.73 295	30	0.26 705	9.94 431	7	36
			24		31			7	
	25	9.67 750		9.73 326		0.26 674	9.94 424		35
	26	9.67 773	23	9.73 356	30	0.26 644	9.94 417	7	34
	27	9.67 796	23	9.73 386	30	0.26 614	9.94 410	7	33
	28	9.67 820	24	9.73 416	30	0.26 584	9.94 404	6	32
	29	9.67 843	23	9.73 446	30	0.26 554	9.94 397	7	31
			23		30			7	
	30	9.67 866		9.73 476		0.26 524	9.94 390		30
	31	9.67 890	24	9.73 507	31	0.26 493	9.94 383	7	29
	32	9.76 913	23	9.73 537	30	0.26 463	9.94 376	7	28
	33	9.67 936	23	9.73 567	30	0.26 433	9.94 369	7	27
	34	9.67 959	23	9.73 597	30	0.26 403	9.94 362	7	26
			23		30			7	
	35	9.67 982		9.73 627		0.26 373	9.94 355		25
	36	9.68 006	24	9.73 657	30	0.26 343	9.94 349	6	24
	37	9.68 029	23	9.73 687	30	0.26 313	9.94 342	7	23
	38	9.68 052	23	9.73 717	30	0.26 283	9.94 335	7	22
	39	9.68 075	23	9.73 747	30	0.26 253	9.94 328	7	21
			23		30			7	
	40	9.68 098		9.73 777		0.26 223	9.94 321		20
	41	9.68 121	23	9.73 807	30	0.26 193	9.94 314	7	19
	42	9.68 144	23	9.73 837	30	0.26 163	9.94 307	7	18
	43	9.68 167	23	9.73 867	30	0.26 133	9.94 300	7	17
	44	9.68 190	23	9.73 897	30	0.26 103	9.94 293	7	16
			23		30			7	
	45	9.68 213		9.73 927		0.26 073	9.94 286		15
	46	9.68 237	24	9.73 957	30	0.26 043	9.94 279	7	14
	47	9.68 260	23	9.73 987	30	0.26 013	9.94 273	6	13
	48	9.68 283	23	9.74 017	30	0.25 983	9.94 266	7	12
	49	9.68 305	22	9.74 047	30	0.25 953	9.94 259	7	11
			23		30			7	
	50	9.68 328		9.74 077		0.25 923	9.94 252		10
	51	9.68 351	23	9.74 107	30	0.25 893	9.94 245	7	9
	52	9.68 374	23	9.74 137	30	0.25 863	9.94 238	7	8
	53	9.68 397	23	9.74 166	29	0.25 834	9.94 231	7	7
	54	9.68 420	23	9.74 196	30	0.25 804	9.94 224	7	6
			23		30			7	
	55	9.68 443		9.74 226		0.25 774	9.94 217		5
	56	9.68 466	23	9.74 256	30	0.25 744	9.94 210	7	4
	57	9.68 489	23	9.74 286	30	0.25 714	9.94 203	7	3
	58	9.68 512	23	9.74 316	30	0.25 684	9.94 196	7	2
	59	9.68 534	22	9.74 345	29	0.25 655	9.94 189	7	1
			23		30			7	
	60	9.68 557		9.74 375		0.25 625	9.94 182		0
		L SIN	D	L TAN	CD	L COT	L COS	D	331°...151°
		L COS		L COT		L TAN	L SIN		241°... 61°

29°...209°		L SIN	D	L TAN	CD	L COT	L COS	D	
119°...299°		L COS		L COT		L TAN	L SIN		
	0	9.68 557	23	9.74 375	30	0.25 625	9.94 182	7	60
	1	9.68 580		9.74 405		0.25 595	9.94 175		59
	2	9.68 603		9.74 435		0.25 565	9.94 168		58
	3	9.68 625		9.74 465		0.25 535	9.94 161		57
	4	9.68 648		9.74 494		0.25 506	9.94 154		56
	5	9.68 671	23	9.74 524	30	0.25 476	9.94 147	7	55
	6	9.68 694		9.74 554		0.25 446	9.94 140		54
	7	9.68 716		9.74 583		0.25 417	9.94 133		53
	8	9.68 739		9.74 613		0.25 387	9.94 126		52
	9	9.68 762		9.74 643		0.25 357	9.94 119		51
	10	9.68 784	23	9.74 673	29	0.25 327	9.94 112	7	50
	11	9.68 807		9.74 702		0.25 298	9.94 105		49
	12	9.68 829		9.74 732		0.25 268	9.94 098		48
	13	9.68 852		9.74 762		0.25 238	9.94 090		47
	14	9.68 875		9.74 791		0.25 209	9.94 083		46
	15	9.68 897	23	9.74 821	30	0.25 179	9.94 076	7	45
	16	9.68 920		9.74 851		0.25 149	9.94 069		44
	17	9.68 942		9.74 880		0.25 120	9.94 062		43
	18	9.68 965		9.74 910		0.25 090	9.94 055		42
	19	9.68 987		9.74 939		0.25 061	9.94 048		41
	20	9.69 010	22	9.74 969	29	0.25 031	9.94 041	7	40
	21	9.69 032		9.74 998		0.25 002	9.94 034		39
	22	9.69 055		9.75 028		0.24 972	9.94 027		38
	23	9.69 077		9.75 058		0.24 942	9.94 020		37
	24	9.69 100		9.75 087		0.24 913	9.94 012		36
	25	9.69 122	22	9.75 117	29	0.24 883	9.94 005	7	35
	26	9.69 144		9.75 146		0.24 854	9.93 998		34
	27	9.69 167		9.75 176		0.24 824	9.93 991		33
	28	9.69 189		9.75 205		0.24 795	9.93 984		32
	29	9.69 212		9.75 235		0.24 765	9.93 977		31
	30	9.69 234	22	9.75 264	30	0.24 736	9.93 970	7	30
	31	9.69 256		9.75 294		0.24 706	9.93 963		29
	32	9.69 279		9.75 323		0.24 677	9.93 955		28
	33	9.69 301		9.75 353		0.24 647	9.93 948		27
	34	9.69 323		9.75 382		0.24 618	9.93 941		26
	35	9.69 345	23	9.75 411	30	0.24 589	9.93 934	7	25
	36	9.69 368		9.75 441		0.24 559	9.93 927		24
	37	9.69 390		9.75 470		0.24 530	9.93 920		23
	38	9.69 412		9.75 500		0.24 500	9.93 912		22
	39	9.69 434		9.75 529		0.24 471	9.93 905		21
	40	9.69 456	23	9.75 558	30	0.24 442	9.93 898	7	20
	41	9.69 479		9.75 588		0.24 412	9.93 891		19
	42	9.69 501		9.75 617		0.24 383	9.93 884		18
	43	9.69 523		9.75 647		0.24 353	9.93 876		17
	44	9.69 545		9.75 676		0.24 324	9.93 869		16
	45	9.69 567	22	9.75 705	30	0.24 295	9.93 862	7	15
	46	9.69 589		9.75 735		0.24 265	9.93 855		14
	47	9.69 611		9.75 764		0.24 236	9.93 847		13
	48	9.69 633		9.75 793		0.24 207	9.93 840		12
	49	9.69 655		9.75 822		0.24 178	9.93 833		11
	50	9.69 677	22	9.75 852	29	0.24 148	9.93 826	7	10
	51	9.69 699		9.75 881		0.24 119	9.93 819		9
	52	9.69 721		9.75 910		0.24 090	9.93 811		8
	53	9.69 743		9.75 939		0.24 061	9.93 804		7
	54	9.69 765		9.75 969		0.24 031	9.93 797		6
	55	9.69 787	22	9.75 998	29	0.24 002	9.93 789	7	5
	56	9.69 809		9.76 027		0.23 973	9.93 782		4
	57	9.69 831		9.76 056		0.23 944	9.93 775		3
	58	9.69 853		9.76 086		0.23 914	9.93 768		2
	59	9.69 875		9.76 115		0.23 885	9.93 760		1
	60	9.69 897		9.76 144		0.23 856	9.93 753		0
		L SIN	D	L TAN	CD	L COT	L COS	D	330°...150°
		L COS		L COT		L TAN	L SIN		240°... 60°

30° ...210°		L SIN	D	L TAN	CD	L COT	L COS	D		
120° ...300°		L COS		L COT		L TAN	L SIN			
	0	9.69 897	22	9.76 144	29	0.23 856	9.93 753	7	60	
	1	9.69 919		9.76 173		0.23 827	9.93 746	8	59	
	2	9.69 941		9.76 202		0.23 798	9.93 738	7	58	
	3	9.69 963		9.76 231		0.23 769	9.93 731	7	57	
	4	9.69 984	21	9.76 261	30	0.23 739	9.93 724	7	56	
			22		29			7		
	5	9.70 006	22	9.76 290	29	0.23 710	9.93 717	8	55	
	6	9.70 028		9.76 319		0.23 681	9.93 709	7	54	
	7	9.70 050		9.76 348		0.23 652	9.93 702	7	53	
	8	9.70 072		9.76 377		0.23 623	9.93 695	7	52	
	9	9.70 093	21	9.76 406	29	0.23 594	9.93 687	8	51	
			22		29			7		
	10	9.70 115	22	9.76 435	29	0.23 565	9.93 680	7	50	
	11	9.70 137		9.76 464		0.23 536	9.93 673	8	49	
	12	9.70 159		9.76 493		0.23 507	9.93 665	7	48	
	13	9.70 180		9.76 522		0.23 478	9.93 658	7	47	
	14	9.70 202	22	9.76 551	29	0.23 449	9.93 650	8	46	
			22		29			7		
	15	9.70 224	21	9.76 580	29	0.23 420	9.93 643	7	45	
	16	9.70 245		9.76 609		0.23 391	9.93 636	8	44	
	17	9.70 267		9.76 639		0.23 361	9.93 628	7	43	
	18	9.70 288		9.76 668		0.23 332	9.93 621	7	42	
	19	9.70 310	22	9.76 697	29	0.23 303	9.93 614	7	41	
			22		28			8		
	20	9.70 332	21	9.76 725	29	0.23 275	9.93 606	7	40	
	21	9.70 353		9.76 754		0.23 246	9.93 599	8	39	
	22	9.70 375		9.76 783		0.23 217	9.93 591	7	38	
	23	9.70 396		9.76 812		0.23 188	9.93 584	7	37	
	24	9.70 418	22	9.76 841	29	0.23 159	9.93 577	7	36	
			21		29			8		
	25	9.70 439	22	9.76 870	29	0.23 130	9.93 569	7	35	
	26	9.70 461		9.76 899		0.23 101	9.93 562	8	34	
	27	9.70 482		9.76 928		0.23 072	9.93 554	7	33	
	28	9.70 504		9.76 957		0.23 043	9.93 547	7	32	
	29	9.70 525	21	9.76 986	29	0.23 014	9.93 539	8	31	
			22		29			7		
	30	9.70 547	21	9.77 015	29	0.22 985	9.93 532	7	30	
	31	9.70 568		9.77 044		0.22 956	9.93 525	8	29	
	32	9.70 590		9.77 073		0.22 927	9.93 517	7	28	
	33	9.70 611		9.77 101		0.22 899	9.93 510	7	27	
	34	9.70 633	22	9.77 130	29	0.22 870	9.93 502	8	26	
			21		29			7		
	35	9.70 654	21	9.77 159	29	0.22 841	9.93 495	8	25	
	36	9.70 675		9.77 188		0.22 812	9.93 487	7	24	
	37	9.70 697		9.77 217		0.22 783	9.93 480	7	23	
	38	9.70 718		9.77 246		0.22 754	9.93 472	8	22	
	39	9.70 739	21	9.77 274	28	0.22 726	9.93 465	7	21	
			22		29			8		
	40	9.70 761	21	9.77 303	29	0.22 697	9.93 457	7	20	
	41	9.70 782		9.77 332		0.22 668	9.93 450	8	19	
	42	9.70 803		9.77 361		0.22 639	9.93 442	7	18	
	43	9.70 824		9.77 390		0.22 610	9.93 435	7	17	
	44	9.70 846	22	9.77 418	28	0.22 582	9.93 427	8	16	
			21		29			7		
	45	9.70 867	21	9.77 447	29	0.22 553	9.93 420	8	15	
	46	9.70 888		9.77 476		0.22 524	9.93 412	7	14	
	47	9.70 909		9.77 505		0.22 495	9.93 405	7	13	
	48	9.70 931		9.77 533		0.22 467	9.93 397	8	12	
	49	9.70 952	21	9.77 562	29	0.22 438	9.93 390	7	11	
			21		29			8		
50	9.70 973	21	9.77 591	28	0.22 409	9.93 382	7	10		
51	9.70 994		9.77 619		0.22 381	9.93 375	8	9		
52	9.71 015		9.77 648		0.22 352	9.93 367	7	8		
53	9.71 036		9.77 677		0.22 323	9.93 360	7	7		
54	9.71 058	22	9.77 706	29	0.22 294	9.93 352	8	6		
		21		28			8			
55	9.71 079	21	9.77 734	29	0.22 266	9.93 344	7	5		
56	9.71 100		9.77 763		0.22 237	9.93 337	8	4		
57	9.71 121		9.77 791		0.22 209	9.93 329	7	3		
58	9.71 142		9.77 820		0.22 180	9.93 322	7	2		
59	9.71 163	21	9.77 849	29	0.22 151	9.93 314	8	1		
		21		28			7			
60	9.71 184		9.77 877		0.22 123	9.93 307		0		
		L SIN	D	L TAN	CD	L COT	L COS	D		329° ...149°
		L COS		L COT		L TAN	L SIN			239° ... 59°

31° ... 211°		L SIN		L TAN		L COT	L COS		
121° ... 301°		L COS	D	L COT	CD	L TAN	L SIN	D	
	0	9.71 184		9.77 877		0.22 123	9.93 307		60
	1	9.71 205	21	9.77 906	29	0.22 094	9.93 299	8	59
	2	9.71 226	21	9.77 935	29	0.22 085	9.93 291	8	58
	3	9.71 247	21	9.77 963	28	0.22 037	9.93 284	7	57
	4	9.71 268	21	9.77 992	29	0.22 008	9.93 276	8	56
			21		28			7	
	5	9.71 289		9.78 020		0.21 980	9.93 269		55
	6	9.71 310	21	9.78 049	29	0.21 951	9.93 261	8	54
	7	9.71 331	21	9.78 077	28	0.21 923	9.93 253	8	53
	8	9.71 352	21	9.78 106	29	0.21 894	9.93 246	7	52
	9	9.71 373	21	9.78 135	29	0.21 865	9.93 238	8	51
			20		28			8	
	10	9.71 393		9.78 163		0.21 837	9.93 230		50
	11	9.71 414	21	9.78 192	29	0.21 808	9.93 223	7	49
	12	9.71 435	21	9.78 220	28	0.21 780	9.93 215	8	48
	13	9.71 456	21	9.78 249	29	0.21 751	9.93 207	8	47
	14	9.71 477	21	9.78 277	28	0.21 723	9.93 200	7	46
			21		29			8	
	15	9.71 498		9.78 306		0.21 694	9.93 192		45
	16	9.71 519	21	9.78 334	28	0.21 666	9.93 184	8	44
	17	9.71 539	20	9.78 363	29	0.21 637	9.93 177	7	43
	18	9.71 560	21	9.78 391	28	0.21 609	9.93 169	8	42
	19	9.71 581	21	9.78 419	28	0.21 581	9.93 161	8	41
			21		29			7	
	20	9.71 602		9.78 448		0.21 552	9.93 154		40
	21	9.71 622	20	9.78 476	28	0.21 524	9.93 146	8	39
	22	9.71 643	21	9.78 505	29	0.21 495	9.93 138	8	38
	23	9.71 664	21	9.78 533	28	0.21 467	9.93 131	7	37
	24	9.71 685	21	9.78 562	29	0.21 438	9.93 123	8	36
			20		28			8	
	25	9.71 705		9.78 590		0.21 410	9.93 115		35
	26	9.71 726	21	9.78 618	28	0.21 382	9.93 108	7	34
	27	9.71 747	21	9.78 647	29	0.21 353	9.93 100	8	33
	28	9.71 767	20	9.78 675	28	0.21 325	9.93 092	8	32
	29	9.71 788	21	9.78 704	29	0.21 296	9.93 084	8	31
			21		28			7	
	30	9.71 809		9.78 732		0.21 268	9.93 077		30
	31	9.71 829	20	9.78 760	28	0.21 240	9.93 069	8	29
	32	9.71 850	21	9.78 789	29	0.21 211	9.93 061	8	28
	33	9.71 870	20	9.78 817	28	0.21 183	9.93 053	8	27
	34	9.71 891	21	9.78 845	28	0.21 155	9.93 046	7	26
			20		29			8	
	35	9.71 911		9.78 874		0.21 126	9.93 038		25
	36	9.71 932	21	9.78 902	28	0.21 098	9.93 030	8	24
	37	9.71 952	20	9.78 930	28	0.21 070	9.93 022	8	23
	38	9.71 973	21	9.78 959	29	0.21 041	9.93 014	8	22
	39	9.71 994	21	9.78 987	28	0.21 013	9.93 007	7	21
			20		28			8	
	40	9.72 014		9.79 015		0.20 985	9.92 999		20
	41	9.72 034	20	9.79 043	28	0.20 957	9.92 991	8	19
	42	9.72 055	21	9.79 072	29	0.20 928	9.92 983	8	18
	43	9.72 075	20	9.79 100	28	0.20 900	9.92 976	7	17
	44	9.72 096	21	9.79 128	28	0.20 872	9.92 968	8	16
			20		28			8	
	45	9.72 116		9.79 156		0.20 844	9.92 960		15
	46	9.72 137	21	9.79 185	29	0.20 815	9.92 952	8	14
	47	9.72 157	20	9.79 213	28	0.20 787	9.92 944	8	13
	48	9.72 177	20	9.79 241	28	0.20 759	9.92 936	8	12
	49	9.72 198	21	9.79 269	28	0.20 731	9.92 929	7	11
			20		28			8	
	50	9.72 218		9.79 297		0.20 703	9.92 921		10
	51	9.72 238	20	9.79 326	29	0.20 674	9.92 913	8	9
	52	9.72 259	21	9.79 354	28	0.20 646	9.92 905	8	8
	53	9.72 279	20	9.79 382	28	0.20 618	9.92 897	8	7
	54	9.72 299	20	9.79 410	28	0.20 590	9.92 889	8	6
			21		28			8	
	55	9.72 320		9.79 438		0.20 562	9.92 881		5
	56	9.72 340	20	9.79 466	28	0.20 534	9.92 874	7	4
	57	9.72 360	20	9.79 495	29	0.20 505	9.92 866	8	3
	58	9.72 381	21	9.79 523	28	0.20 477	9.92 858	8	2
	59	9.72 401	20	9.79 551	28	0.20 449	9.92 850	8	1
			20		28			8	
	60	9.72 421		9.79 579		0.20 421	9.92 842		0
		L SIN	D	L TAN	CD	L COT	L COS	D	328° ... 148°
		L COS		L COT		L TAN	L SIN		238° ... 58°

32°...212°		L SIN	D	L TAN	CD	L COT	L COS	D	
122°...302°		L COS		L COT		L TAN	L SIN		
	0	9.72 421	20	9.79 579	28	0.20 421	9.92 842	8	60
	1	9.72 441	20	9.79 607	28	0.20 393	9.92 834	8	59
	2	9.72 461	21	9.79 635	28	0.20 365	9.92 826	8	58
	3	9.72 482	20	9.79 663	28	0.20 337	9.92 818	8	57
	4	9.72 502	20	9.79 691	28	0.20 309	9.92 810	8	56
			20		28			7	
	5	9.72 522		9.79 719		0.20 281	9.92 803		55
	6	9.72 542	20	9.79 747	28	0.20 253	9.92 795	8	54
	7	9.72 562	20	9.79 776	29	0.20 224	9.92 787	8	53
	8	9.72 582	20	9.79 804	28	0.20 196	9.92 779	8	52
	9	9.72 602	20	9.79 832	28	0.20 168	9.92 771	8	51
			20		28			8	
	10	9.72 622		9.79 860		0.20 140	9.92 763		50
	11	9.72 643	21	9.79 888	28	0.20 112	9.92 755	8	49
	12	9.72 663	20	9.79 916	28	0.20 084	9.92 747	8	48
	13	9.72 683	20	9.79 944	28	0.20 056	9.92 739	8	47
	14	9.72 703	20	9.79 972	28	0.20 028	9.92 731	8	46
			20		28			8	
	15	9.72 723		9.80 000		0.20 000	9.92 723		45
	16	9.72 743	20	9.80 028	28	0.19 972	9.92 715	8	44
	17	9.72 763	20	9.80 056	28	0.19 944	9.92 707	8	43
	18	9.72 783	20	9.80 084	28	0.19 916	9.92 699	8	42
	19	9.72 803	20	9.80 112	28	0.19 888	9.92 691	8	41
			20		28			8	
	20	9.72 823	20	9.80 140	28	0.19 860	9.92 683	8	40
	21	9.72 843	20	9.80 168	27	0.19 832	9.92 675	8	39
	22	9.72 863	20	9.80 195	28	0.19 805	9.92 667	8	38
	23	9.72 883	20	9.80 223	28	0.19 777	9.92 659	8	37
	24	9.72 902	19	9.80 251	28	0.19 749	9.92 651	8	36
			20		28			8	
	25	9.72 922		9.80 279		0.19 721	9.92 643		35
	26	9.72 942	20	9.80 307	28	0.19 693	9.92 635	8	34
	27	9.72 962	20	9.80 335	28	0.19 665	9.92 627	8	33
	28	9.72 982	20	9.80 363	28	0.19 637	9.92 619	8	32
	29	9.73 002	20	9.80 391	28	0.19 609	9.92 611	8	31
			20		28			8	
	30	9.73 022		9.80 419		0.19 581	9.92 603		30
	31	9.73 041	19	9.80 447	28	0.19 553	9.92 595	8	29
	32	9.73 061	20	9.80 474	27	0.19 526	9.92 587	8	28
	33	9.73 081	20	9.80 502	28	0.19 498	9.92 579	8	27
	34	9.73 101	20	9.80 530	28	0.19 470	9.92 571	8	26
			20		28			8	
	35	9.73 121		9.80 558		0.19 442	9.92 563		25
	36	9.73 140	19	9.80 586	28	0.19 414	9.92 555	8	24
	37	9.73 160	20	9.80 614	28	0.19 386	9.92 546	9	23
	38	9.73 180	20	9.80 642	28	0.19 358	9.92 538	8	22
	39	9.73 200	20	9.80 669	27	0.19 331	9.92 530	8	21
			19		28			8	
	40	9.73 219		9.80 697		0.19 303	9.92 522		20
	41	9.73 239	20	9.80 725	28	0.19 275	9.92 514	8	19
	42	9.73 259	20	9.80 753	28	0.19 247	9.92 506	8	18
	43	9.73 278	19	9.80 781	28	0.19 219	9.92 498	8	17
	44	9.73 298	20	9.80 808	27	0.19 192	9.92 490	8	16
			20		28			8	
	45	9.73 318		9.80 836		0.19 164	9.92 482		15
	46	9.73 337	19	9.80 864	28	0.19 136	9.92 473	9	14
	47	9.73 357	20	9.80 892	28	0.19 108	9.92 465	8	13
	48	9.73 377	20	9.80 919	27	0.19 081	9.92 457	8	12
	49	9.73 396	19	9.80 947	28	0.19 053	9.92 449	8	11
			20		28			8	
	50	9.73 416		9.80 975		0.19 025	9.92 441		10
	51	9.73 435	19	9.81 003	28	0.18 997	9.92 433	8	9
	52	9.73 455	20	9.81 030	27	0.18 970	9.92 425	8	8
	53	9.73 474	19	9.81 058	28	0.18 942	9.92 416	9	7
	54	9.73 494	20	9.81 086	28	0.18 914	9.92 408	8	6
			19		27			8	
	55	9.73 513		9.81 113		0.18 887	9.92 400		5
	56	9.73 533	20	9.81 141	28	0.18 859	9.92 392	8	4
	57	9.73 552	19	9.81 169	28	0.18 831	9.92 384	8	3
	58	9.73 572	20	9.81 196	27	0.18 804	9.92 376	8	2
	59	9.73 591	19	9.81 224	28	0.18 776	9.92 367	9	1
			20		28			8	
	60	9.73 611		9.81 252		0.18 748	9.92 359		0
		L SIN	D	L TAN	CD	L COT	L COS	D	227°...147°
		L COS		L COT		L TAN	L SIN		237°... 57°

33°...213°		L SIN		L TAN		L COT	L COS		
123°...303°		L COS	D	L COT	CD	L TAN	L SIN	D	
	0	9.73 611		9.81 252	27	0.18 748	9.92 359	8	60
	1	9.73 630	19	9.81 279	28	0.18 721	9.92 351	8	59
	2	9.73 650	20	9.81 307	28	0.18 693	9.92 343	8	58
	3	9.73 669	19	9.81 335	28	0.18 665	9.92 335	8	57
	4	9.73 689	20	9.81 362	27	0.18 638	9.92 326	9	56
			19		28			8	
	5	9.73 708		9.81 390	28	0.18 610	9.92 318	8	55
	6	9.73 727	19	9.81 418	27	0.18 582	9.92 310	8	54
	7	9.73 747	20	9.81 445	27	0.18 555	9.92 302	8	53
	8	9.73 766	19	9.81 473	28	0.18 527	9.92 293	9	52
	9	9.73 785	19	9.81 500	27	0.18 500	9.92 285	8	51
			20		28			8	
	10	9.73 805		9.81 528	28	0.18 472	9.92 277	8	50
	11	9.73 824	19	9.81 556	27	0.18 444	9.92 269	9	49
	12	9.73 843	19	9.81 583	27	0.18 417	9.92 260	9	48
	13	9.73 863	20	9.81 611	28	0.18 389	9.92 252	8	47
	14	9.73 882	19	9.81 638	27	0.18 362	9.92 244	8	46
			19		28			9	
	15	9.73 901		9.81 666	27	0.18 334	9.92 235	8	45
	16	9.73 921	20	9.81 693	27	0.18 307	9.92 227	8	44
	17	9.73 940	19	9.81 721	28	0.18 279	9.92 219	8	43
	18	9.73 959	19	9.81 748	27	0.18 252	9.92 211	8	42
	19	9.73 978	19	9.81 776	28	0.18 224	9.92 202	9	41
			19		27			8	
	20	9.73 997		9.81 803	28	0.18 197	9.92 194	8	40
	21	9.74 017	20	9.81 831	27	0.18 169	9.92 186	8	39
	22	9.74 036	19	9.81 858	27	0.18 142	9.92 177	9	38
	23	9.74 055	19	9.81 886	28	0.18 114	9.92 169	8	37
	24	9.74 074	19	9.81 913	27	0.18 087	9.92 161	8	36
			19		28			9	
	25	9.74 093		9.81 941	27	0.18 059	9.92 152	8	35
	26	9.74 113	20	9.81 968	27	0.18 032	9.92 144	8	34
	27	9.74 132	19	9.81 996	28	0.18 004	9.92 136	8	33
	28	9.74 151	19	9.82 023	27	0.17 977	9.92 127	9	32
	29	9.74 170	19	9.82 051	28	0.17 949	9.92 119	8	31
			19		27			8	
	30	9.74 189		9.82 078	28	0.17 922	9.92 111	9	30
	31	9.74 208	19	9.82 106	27	0.17 894	9.92 102	8	29
	32	9.74 227	19	9.82 133	27	0.17 867	9.92 094	8	28
	33	9.74 246	19	9.82 161	28	0.17 839	9.92 086	8	27
	34	9.74 265	19	9.82 188	27	0.17 812	9.92 077	9	26
			19		27			8	
	35	9.74 284		9.82 215	28	0.17 785	9.92 069	9	25
	36	9.74 303	19	9.82 243	27	0.17 757	9.92 060	8	24
	37	9.74 322	19	9.82 270	27	0.17 730	9.92 052	8	23
	38	9.74 341	19	9.82 298	28	0.17 702	9.92 044	8	22
	39	9.74 360	19	9.82 325	27	0.17 675	9.92 035	9	21
			19		27			8	
	40	9.74 379		9.82 352	28	0.17 648	9.92 027	9	20
	41	9.74 398	19	9.82 380	27	0.17 620	9.92 018	8	19
	42	9.74 417	19	9.82 407	27	0.17 593	9.92 010	8	18
	43	9.74 436	19	9.82 435	28	0.17 565	9.92 002	8	17
	44	9.74 455	19	9.82 462	27	0.17 538	9.91 993	9	16
			19		27			8	
	45	9.74 474		9.82 489	28	0.17 511	9.91 985	9	15
	46	9.74 493	19	9.82 517	27	0.17 483	9.91 976	8	14
	47	9.74 512	19	9.82 544	27	0.17 456	9.91 968	8	13
	48	9.74 531	19	9.82 571	27	0.17 429	9.91 959	9	12
	49	9.74 549	18	9.82 599	28	0.17 401	9.91 951	8	11
			19		27			9	
	50	9.74 568		9.82 626	27	0.17 374	9.91 942	8	10
	51	9.74 587	19	9.82 653	28	0.17 347	9.91 934	9	9
	52	9.74 606	19	9.82 681	27	0.17 319	9.91 925	8	8
	53	9.74 625	19	9.82 708	27	0.17 292	9.91 917	8	7
	54	9.74 644	19	9.82 735	27	0.17 265	9.91 908	9	6
			18		27			8	
	55	9.74 662		9.82 762	28	0.17 238	9.91 900	9	5
	56	9.74 681	19	9.82 790	27	0.17 210	9.91 891	8	4
	57	9.74 700	19	9.82 817	27	0.17 183	9.91 883	8	3
	58	9.74 719	19	9.82 844	27	0.17 156	9.91 874	9	2
	59	9.74 737	18	9.82 871	27	0.17 129	9.91 866	8	1
			19		28			9	
	60	9.74 756		9.82 899		0.17 101	9.91 857		0
		L SIN		L TAN		L COT	L COS		326°..146°
		L COS	D	L COT	CD	L TAN	L SIN	D	236°... 56°

34°...214°		L SIN	D	L TAN	CD	L COT	L COS	D			
124°...304°		L COS		L COT		L TAN	L SIN				
	0	9.74 756	19	9.82 899	27	0.17 101	9.91 857	8	60		
	1	9.74 775		9.82 926		0.17 074	9.91 849		9	59	
	2	9.74 794		9.82 953		0.17 047	9.91 840		8	58	
	3	9.74 812		9.82 980		0.17 020	9.91 832		8	57	
	4	9.74 831	19	9.83 008	27	0.16 992	9.91 823	9	56		
	5	9.74 850		9.83 035		0.16 956	9.91 815		8	55	
	6	9.74 868		9.83 062		0.16 938	9.91 806		9	54	
	7	9.74 887		9.83 089		0.16 911	9.91 798		8	53	
	8	9.74 906	18	9.83 117	27	0.16 883	9.91 789	9	52		
	9	9.74 924		9.83 144		0.16 856	9.91 781		8	51	
	10	9.74 943		9.83 171		0.16 829	9.91 772		9	50	
	11	9.74 961		9.83 198		0.16 802	9.91 763		8	49	
	12	9.74 980	19	9.83 225	27	0.16 775	9.91 755	9	48		
	13	9.74 999		9.83 252		0.16 748	9.91 746		8	47	
	14	9.75 017		9.83 280		0.16 720	9.91 738		9	46	
	15	9.75 036		9.83 307		0.16 693	9.91 729		8	45	
	16	9.75 054	18	9.83 334	27	0.16 666	9.91 720	9	44		
	17	9.75 073		9.83 361		0.16 639	9.91 712		8	43	
	18	9.75 091		9.83 388		0.16 612	9.91 703		9	42	
	19	9.75 110		9.83 415		0.16 585	9.91 695		8	41	
	20	9.75 128	19	9.83 442	27	0.16 558	9.91 686	9	40		
	21	9.75 147		9.83 470		0.16 530	9.91 677		8	39	
	22	9.75 165		9.83 497		0.16 503	9.91 669		9	38	
	23	9.75 184		9.83 524		0.16 476	9.91 660		8	37	
	24	9.75 202	18	9.83 551	27	0.16 449	9.91 651	9	36		
	25	9.75 221		9.83 578		0.16 422	9.91 643		8	35	
	26	9.75 239		9.83 605		0.16 395	9.91 634		9	34	
	27	9.75 258		9.83 632		0.16 368	9.91 625		8	33	
	28	9.75 276	18	9.83 659	27	0.16 341	9.91 617	9	32		
	29	9.75 294		9.83 686		0.16 314	9.91 608		8	31	
	30	9.75 313		9.83 713		0.16 287	9.91 599		9	30	
	31	9.75 331		9.83 740		0.16 260	9.91 591		8	29	
	32	9.75 350	19	9.83 768	27	0.16 232	9.91 582	9	28		
	33	9.75 368		9.83 795		0.16 205	9.91 573		8	27	
	34	9.75 386		9.83 822		0.16 178	9.91 565		9	26	
	35	9.75 405		9.83 849		0.16 151	9.91 556		8	25	
	36	9.75 423	18	9.83 876	27	0.16 124	9.91 547	9	24		
	37	9.75 441		9.83 903		0.16 097	9.91 538		8	23	
	38	9.75 459		9.83 930		0.16 070	9.91 530		9	22	
	39	9.75 478		9.83 957		0.16 043	9.91 521		8	21	
	40	9.75 496	18	9.83 984	27	0.16 016	9.91 512	9	20		
	41	9.75 514		9.84 011		0.15 989	9.91 504		8	19	
	42	9.75 533		9.84 038		0.15 962	9.91 495		9	18	
	43	9.75 551		9.84 065		0.15 935	9.91 486		8	17	
	44	9.75 569	18	9.84 092	27	0.15 908	9.91 477	9	16		
	45	9.75 587		9.84 119		0.15 881	9.91 469		8	15	
	46	9.75 605		9.84 146		0.15 854	9.91 460		9	14	
	47	9.75 624		9.84 173		0.15 827	9.91 451		8	13	
	48	9.75 642	18	9.84 200	27	0.15 800	9.91 442	9	12		
	49	9.75 660		9.84 227		0.15 773	9.91 433		8	11	
	50	9.75 678		9.84 254		0.15 746	9.91 425		9	10	
	51	9.75 696		9.84 280		0.15 720	9.91 416		8	9	
	52	9.75 714	19	9.84 307	27	0.15 693	9.91 407	9	8		
	53	9.75 733		9.84 334		0.15 666	9.91 398		8	7	
	54	9.75 751		9.84 361		0.15 639	9.91 389		9	6	
	55	9.75 769		9.84 388		0.15 612	9.91 381		8	5	
	56	9.75 787	18	9.84 415	27	0.15 585	9.91 372	9	4		
	57	9.75 805		9.84 442		0.15 558	9.91 363		8	3	
	58	9.75 823		9.84 469		0.15 531	9.91 354		9	2	
	59	9.75 841		9.84 496		0.15 504	9.91 345		8	1	
60	9.75 859		9.84 523		0.15 477	9.91 336		0			
	L SIN		D		L TAN	CD		L COT	L COS	D	325°...145°
	L COS				L COT			L TAN	L SIN		235°... 55°

35°...215°		L SIN	D	L TAN	CD	L COT	L COS	D	
125°...305°		L COS		L COT		L TAN	L SIN		
	0	9.75 859	18	9.84 523	27	0.15 477	9.91 336	8	60
	1	9.75 877	18	9.84 550	26	0.15 450	9.91 328	9	59
	2	9.75 895	18	9.84 576	27	0.15 424	9.91 319	9	58
	3	9.75 913	18	9.84 603	27	0.15 397	9.91 310	9	57
	4	9.75 931	18	9.84 630	27	0.15 370	9.91 301	9	56
	5	9.75 949	18	9.84 657	27	0.15 343	9.91 292	9	55
	6	9.75 967	18	9.84 684	27	0.15 316	9.91 283	9	54
	7	9.75 985	18	9.84 711	27	0.15 289	9.91 274	9	53
	8	9.76 003	18	9.84 738	27	0.15 262	9.91 266	8	52
	9	9.76 021	18	9.84 764	27	0.15 236	9.91 257	9	51
	10	9.76 039	18	9.84 791	27	0.15 209	9.91 248	9	50
	11	9.76 057	18	9.84 818	27	0.15 182	9.91 239	9	49
	12	9.76 075	18	9.84 845	27	0.15 155	9.91 230	9	48
	13	9.76 093	18	9.84 872	27	0.15 128	9.91 221	9	47
	14	9.76 111	18	9.84 899	26	0.15 101	9.91 212	9	46
	15	9.76 129	17	9.84 925	27	0.15 075	9.91 203	9	45
	16	9.76 146	18	9.84 952	27	0.15 048	9.91 194	9	44
	17	9.76 164	18	9.84 979	27	0.15 021	9.91 185	9	43
	18	9.76 182	18	9.85 006	27	0.14 994	9.91 176	9	42
	19	9.76 200	18	9.85 033	26	0.14 967	9.91 167	9	41
	20	9.76 218	18	9.85 059	27	0.14 941	9.91 158	9	40
	21	9.76 236	17	9.85 086	27	0.14 914	9.91 149	8	39
	22	9.76 253	18	9.85 113	27	0.14 887	9.91 141	9	38
	23	9.76 271	18	9.85 140	26	0.14 860	9.91 132	9	37
	24	9.76 289	18	9.85 166	27	0.14 834	9.91 123	9	36
	25	9.76 307	17	9.85 193	27	0.14 807	9.91 114	9	35
	26	9.76 324	18	9.85 220	27	0.14 780	9.91 105	9	34
	27	9.76 342	18	9.85 247	26	0.14 753	9.91 096	9	33
	28	9.76 360	18	9.85 273	27	0.14 727	9.91 087	9	32
	29	9.76 378	17	9.85 300	27	0.14 700	9.91 078	9	31
	30	9.76 395	18	9.85 327	27	0.14 673	9.91 069	9	30
	31	9.76 413	18	9.85 354	26	0.14 646	9.91 060	9	29
	32	9.76 431	17	9.85 380	27	0.14 620	9.91 051	9	28
	33	9.76 448	18	9.85 407	27	0.14 593	9.91 042	9	27
	34	9.76 466	18	9.85 434	26	0.14 566	9.91 033	10	26
	35	9.76 484	17	9.85 460	27	0.14 540	9.91 023	9	25
	36	9.76 501	18	9.85 487	27	0.14 513	9.91 014	9	24
	37	9.76 519	18	9.85 514	26	0.14 486	9.91 005	9	23
	38	9.76 537	17	9.85 540	27	0.14 460	9.90 996	9	22
	39	9.76 554	18	9.85 567	27	0.14 433	9.90 987	9	21
	40	9.76 572	18	9.85 594	26	0.14 406	9.90 978	9	20
	41	9.76 590	17	9.85 620	27	0.14 380	9.90 969	9	19
	42	9.76 607	18	9.85 647	27	0.14 353	9.90 960	9	18
	43	9.76 625	17	9.85 674	26	0.14 326	9.90 951	9	17
	44	9.76 642	18	9.85 700	27	0.14 300	9.90 942	9	16
	45	9.76 660	17	9.85 727	27	0.14 273	9.90 933	9	15
	46	9.76 677	18	9.85 754	26	0.14 246	9.90 924	9	14
	47	9.76 695	17	9.85 780	27	0.14 220	9.90 915	9	13
	48	9.76 712	18	9.85 807	27	0.14 193	9.90 906	10	12
	49	9.76 730	17	9.85 834	26	0.14 166	9.90 896	9	11
	50	9.76 747	18	9.85 860	27	0.14 140	9.90 887	9	10
	51	9.76 765	17	9.85 887	26	0.14 113	9.90 878	9	9
	52	9.76 782	18	9.85 913	27	0.14 087	9.90 869	9	8
	53	9.76 800	17	9.85 940	27	0.14 060	9.90 860	9	7
	54	9.76 817	18	9.85 967	26	0.14 033	9.90 851	9	6
	55	9.76 835	17	9.85 993	27	0.14 007	9.90 842	10	5
	56	9.76 852	18	9.86 020	26	0.13 980	9.90 832	9	4
	57	9.76 870	17	9.86 046	27	0.13 954	9.90 823	9	3
	58	9.76 887	17	9.86 073	27	0.13 927	9.90 814	9	2
	59	9.76 904	18	9.86 100	26	0.13 900	9.90 805	9	1
	60	9.76 922		9.86 126		0.13 874	9.90 796		0
		L SIN	D	L TAN	CD	L COT	L COS	D	324°...144°
		L COS		L COT		L TAN	L SIN		234°... 54°

36°...216°		L SIN		L TAN		L COT	L COS		
126°...306°		L COS	D	L COT	CD	L TAN	L SIN	D	
	0	9.76 922	17	9.86 126	27	0.13 874	9.90 796	9	60
	1	9.76 939	18	9.86 153	26	0.13 847	9.90 787	10	59
	2	9.76 957	17	9.86 179	27	0.13 821	9.90 777	9	58
	3	9.76 974	17	9.86 206	26	0.13 794	9.90 768	9	57
	4	9.76 991	18	9.86 232	27	0.13 768	9.90 759	9	56
	5	9.77 009	17	9.86 259	26	0.13 741	9.90 750	9	55
	6	9.77 026	17	9.86 285	27	0.13 715	9.90 741	10	54
	7	9.77 043	18	9.86 312	26	0.13 688	9.90 731	9	53
	8	9.77 061	17	9.86 338	27	0.13 662	9.90 722	9	52
	9	9.77 078	17	9.86 365	27	0.13 635	9.90 713	9	51
	10	9.77 095	17	9.86 392	26	0.13 608	9.90 704	10	50
	11	9.77 112	18	9.86 418	27	0.13 582	9.90 694	9	49
	12	9.77 130	17	9.86 445	26	0.13 555	9.90 685	9	48
	13	9.77 147	17	9.86 471	27	0.13 529	9.90 676	9	47
	14	9.77 164	17	9.86 498	26	0.13 502	9.90 667	10	46
	15	9.77 181	18	9.86 524	27	0.13 476	9.90 657	9	45
	16	9.77 199	17	9.86 551	26	0.13 449	9.90 648	9	44
	17	9.77 216	17	9.86 577	26	0.13 423	9.90 639	9	43
	18	9.77 233	17	9.86 603	27	0.13 397	9.90 630	10	42
	19	9.77 250	18	9.86 630	26	0.13 370	9.90 620	9	41
	20	9.77 268	17	9.86 656	27	0.13 344	9.90 611	9	40
	21	9.77 285	17	9.86 683	26	0.13 317	9.90 602	10	39
	22	9.77 302	17	9.86 709	27	0.13 291	9.90 592	9	38
	23	9.77 319	17	9.86 736	26	0.13 264	9.90 583	9	37
	24	9.77 336	17	9.86 762	27	0.13 238	9.90 574	9	36
	25	9.77 353	17	9.86 789	26	0.13 211	9.90 565	10	35
	26	9.77 370	17	9.86 815	27	0.13 185	9.90 555	9	34
	27	9.77 387	18	9.86 842	26	0.13 158	9.90 546	9	33
	28	9.77 405	17	9.86 868	26	0.13 132	9.90 537	10	32
	29	9.77 422	17	9.86 894	27	0.13 106	9.90 527	9	31
	30	9.77 439	17	9.86 921	26	0.13 079	9.90 518	9	30
	31	9.77 456	17	9.86 947	27	0.13 053	9.90 509	10	29
	32	9.77 473	17	9.86 974	26	0.13 026	9.90 499	9	28
	33	9.77 490	17	9.87 000	27	0.13 000	9.90 490	10	27
	34	9.77 507	17	9.87 027	26	0.12 973	9.90 480	9	26
	35	9.77 524	17	9.87 053	26	0.12 947	9.90 471	9	25
	36	9.77 541	17	9.87 079	27	0.12 921	9.90 462	10	24
	37	9.77 558	17	9.87 106	26	0.12 894	9.90 452	9	23
	38	9.77 575	17	9.87 132	26	0.12 868	9.90 443	9	22
	39	9.77 592	17	9.87 158	27	0.12 842	9.90 434	10	21
	40	9.77 609	17	9.87 185	26	0.12 815	9.90 424	9	20
	41	9.77 626	17	9.87 211	27	0.12 789	9.90 415	10	19
	42	9.77 643	17	9.87 238	26	0.12 762	9.90 405	9	18
	43	9.77 660	17	9.87 264	26	0.12 736	9.90 396	10	17
	44	9.77 677	17	9.87 290	27	0.12 710	9.90 386	9	16
	45	9.77 694	17	9.87 317	26	0.12 683	9.90 377	9	15
	46	9.77 711	17	9.87 343	26	0.12 657	9.90 368	10	14
	47	9.77 728	16	9.87 369	27	0.12 631	9.90 358	9	13
	48	9.77 744	17	9.87 396	26	0.12 604	9.90 349	10	12
	49	9.77 761	17	9.87 422	26	0.12 578	9.90 339	9	11
	50	9.77 778	17	9.87 448	27	0.12 552	9.90 330	10	10
	51	9.77 795	17	9.87 475	26	0.12 525	9.90 320	9	9
	52	9.77 812	17	9.87 501	26	0.12 499	9.90 311	10	8
	53	9.77 829	17	9.87 527	27	0.12 473	9.90 301	9	7
	54	9.77 846	16	9.87 554	26	0.12 446	9.90 292	10	6
	55	9.77 862	17	9.87 580	26	0.12 420	9.90 282	9	5
	56	9.77 879	17	9.87 606	27	0.12 394	9.90 273	10	4
	57	9.77 896	17	9.87 633	26	0.12 367	9.90 263	9	3
	58	9.77 913	17	9.87 659	26	0.12 341	9.90 254	10	2
	59	9.77 930	16	9.87 685	26	0.12 315	9.90 244	9	1
	60	9.77 946		9.87 711		0.12 289	9.90 235		0
		L SIN	D	L TAN	CD	L COT	L COS	D	323°...143°
		L COS		L COT		L TAN	L SIN		233°... 53°

37° ... 217°		L SIN	D	L TAN	CD	L COT	L COS	D	
127° ... 307°		L COS		L COT		L TAN	L SIN		
	0	9.77 946	17	9.87 711	27	0.12 289	9.90 235	10	60
	1	9.77 963	17	9.87 738	26	0.12 262	9.90 225	9	59
	2	9.77 980	17	9.87 764	26	0.12 236	9.90 216	10	58
	3	9.77 997	16	9.87 790	27	0.12 210	9.90 206	9	57
	4	9.78 013	17	9.87 817	26	0.12 183	9.90 197	10	56
	5	9.78 030	17	9.87 843	26	0.12 157	9.90 187	9	55
	6	9.78 047	16	9.87 869	26	0.12 131	9.90 178	10	54
	7	9.78 063	17	9.87 895	27	0.12 105	9.90 168	9	53
	8	9.78 080	17	9.87 922	26	0.12 078	9.90 159	10	52
	9	9.78 097	16	9.87 948	26	0.12 052	9.90 149	10	51
	10	9.78 113	17	9.87 974	26	0.12 026	0.90 139	9	50
	11	9.78 130	17	9.88 000	27	0.12 000	9.90 130	10	49
	12	9.78 147	16	9.88 027	26	0.11 973	9.90 120	9	48
	13	9.78 163	17	9.88 053	26	0.11 947	9.90 111	10	47
	14	9.78 180	17	9.88 079	26	0.11 921	9.90 101	10	46
	15	9.78 197	16	9.88 105	26	0.11 895	9.90 091	9	45
	16	9.78 213	17	9.88 131	27	0.11 869	9.90 082	10	44
	17	9.78 230	16	9.88 158	26	0.11 842	9.90 072	9	43
	18	9.78 246	17	9.88 184	26	0.11 816	9.90 063	10	42
	19	9.78 263	17	9.88 210	26	0.11 790	9.90 053	10	41
	20	9.78 280	16	9.88 236	26	0.11 764	9.90 043	9	40
	21	9.78 296	17	9.88 262	27	0.11 738	9.90 034	10	39
	22	9.78 313	16	9.88 289	26	0.11 711	9.90 024	10	38
	23	9.78 329	17	9.88 315	26	0.11 685	9.90 014	9	37
	24	9.78 346	16	9.88 341	26	0.11 659	9.90 005	10	36
	25	9.78 362	17	9.88 367	26	0.11 633	9.89 995	10	35
	26	9.78 379	16	9.88 393	27	0.11 607	9.89 985	9	34
	27	9.78 395	17	9.88 420	26	0.22 580	9.89 976	10	33
	28	9.78 412	16	9.88 446	26	0.11 554	9.89 966	10	32
	29	9.78 428	17	9.88 472	26	0.11 528	9.89 956	9	31
	30	9.78 445	16	9.88 498	26	0.11 502	9.89 947	10	30
	31	9.78 461	17	9.88 524	26	0.11 476	9.89 937	10	29
	32	9.78 478	16	9.88 550	27	0.11 450	9.89 927	9	28
	33	9.78 494	16	9.88 577	26	0.11 423	9.89 918	10	27
	34	9.78 510	17	9.88 603	26	0.11 397	9.89 908	10	26
	35	9.78 527	16	9.88 629	26	0.11 371	9.89 898	10	25
	36	9.78 543	17	9.88 655	26	0.11 345	9.89 888	9	24
	37	9.78 560	16	9.88 681	26	0.11 319	9.89 879	10	23
	38	9.78 576	16	9.88 707	26	0.11 293	0.89 869	10	22
	39	9.78 592	17	9.88 733	26	0.11 267	9.89 859	10	21
	40	9.78 609	16	9.88 759	27	0.11 241	9.89 849	9	20
	41	9.78 625	17	9.88 786	26	0.11 214	9.89 840	10	19
	42	9.78 642	16	9.88 812	26	0.11 188	9.89 830	10	18
	43	9.78 658	16	9.88 838	26	0.11 162	9.89 820	10	17
	44	9.78 674	17	9.88 864	26	0.11 136	9.89 810	10	16
	45	9.78 691	16	9.88 890	26	0.11 110	9.89 801	9	15
	46	9.78 707	16	9.88 916	26	0.11 084	9.89 791	10	14
	47	9.78 723	16	9.88 942	26	0.11 058	9.89 781	10	13
	48	9.78 739	17	9.88 968	26	0.11 032	9.89 771	10	12
	49	9.78 756	16	9.88 994	26	0.11 006	0.89 761	10	11
	50	9.78 772	16	0.89 020	26	0.10 980	9.89 752	10	10
	51	9.78 788	17	9.89 046	27	0.10 954	9.89 742	10	9
	52	9.78 805	16	9.89 073	26	0.10 927	9.89 732	10	8
	53	9.78 821	16	9.89 099	26	0.10 901	9.89 722	10	7
	54	9.78 837	16	9.89 125	26	0.10 875	9.89 712	10	6
	55	9.78 853	16	9.89 151	26	0.10 849	9.89 702	9	5
	56	9.78 869	17	9.89 177	26	0.10 823	9.89 693	10	4
	57	9.78 886	16	9.89 203	26	0.10 797	9.89 683	10	3
	58	9.78 902	16	9.89 229	26	0.10 771	0.89 673	10	2
	59	9.78 918	16	9.89 255	26	0.10 745	9.89 663	10	1
	60	9.78 934	16	9.89 281	26	0.10 719	9.89 653	10	0
		L SIN	D	L TAN	CD	L COT	L COS	D	322° ... 142°
		L COS		L COT		L TAN	L SIN		232° ... 52°

38°...218°		L SIN	D	L TAN	CD	L COT	L COS	D	
128°...308°		L COS		L COT		L TAN	L SIN		
	0	9.78 934	16	9.89 281	26	0.10 719	9.89 653	10	60
	1	9.78 950	17	9.89 307	26	0.10 693	9.89 643	10	59
	2	9.78 967	16	9.89 333	26	0.10 667	9.89 633	10	58
	3	9.78 983	16	9.89 359	26	0.10 641	9.89 624	9	57
	4	9.78 999	16	9.89 385	26	0.10 615	9.89 614	10	56
	5	9.79 015	16	9.89 411	26	0.10 589	9.89 604	10	55
	6	9.79 031	16	9.89 437	26	0.10 563	9.89 594	10	54
	7	9.79 047	16	9.89 463	26	0.10 537	9.89 584	10	53
	8	9.79 063	16	9.89 489	26	0.10 511	9.89 574	10	52
	9	9.79 079	16	9.89 515	26	0.10 485	9.89 564	10	51
	10	9.79 095	16	9.89 541	26	0.10 459	9.89 554	10	50
	11	9.79 111	17	9.89 567	26	0.10 433	9.89 544	10	49
	12	9.79 128	16	9.89 593	26	0.10 407	9.89 534	10	48
	13	9.79 144	16	9.89 619	26	0.10 381	9.89 524	10	47
	14	9.79 160	16	9.89 645	26	0.10 355	9.89 514	10	46
	15	9.79 176	16	9.89 671	26	0.10 329	9.89 504	9	45
	16	9.79 192	16	9.89 697	26	0.10 303	9.89 495	10	44
	17	9.79 208	16	9.89 723	26	0.10 277	9.89 485	10	43
	18	9.79 224	16	9.89 749	26	0.10 251	9.89 475	10	42
	19	9.79 240	16	9.89 775	26	0.10 225	9.89 465	10	41
	20	9.79 256	16	9.89 801	26	0.10 199	9.89 455	10	40
	21	9.79 272	16	9.89 827	26	0.10 173	9.89 445	10	39
	22	9.79 288	16	9.89 853	26	0.10 147	9.89 435	10	38
	23	9.79 304	15	9.89 879	26	0.10 121	9.89 425	10	37
	24	9.79 319	16	9.89 905	26	0.10 095	9.89 415	10	36
	25	9.79 335	16	9.89 931	26	0.10 069	9.89 405	10	35
	26	9.79 351	16	9.89 957	26	0.10 043	9.89 395	10	34
	27	9.79 367	16	9.89 983	26	0.10 017	9.89 385	10	33
	28	9.79 383	16	9.90 009	26	0.09 991	9.89 375	10	32
	29	9.79 399	16	9.90 035	26	0.09 965	9.89 364	11	31
	30	9.79 415	16	9.90 061	25	0.09 939	9.89 354	10	30
	31	9.79 431	16	9.90 086	26	0.09 914	9.89 344	10	29
	32	9.79 447	16	9.90 112	26	0.09 888	9.89 334	10	28
	33	9.79 463	15	9.90 138	26	0.09 862	9.89 324	10	27
	34	9.79 478	16	9.90 164	26	0.09 836	9.89 314	10	26
	35	9.79 494	16	9.90 190	26	0.09 810	9.89 304	10	25
	36	9.79 510	16	9.90 216	26	0.09 784	9.89 294	10	24
	37	9.79 526	16	9.90 242	26	0.09 758	9.89 284	10	23
	38	9.79 542	16	9.90 268	26	0.09 732	9.89 274	10	22
	39	9.79 558	15	9.90 294	26	0.09 706	9.89 264	10	21
	40	9.79 573	16	9.90 320	26	0.09 680	9.89 254	10	20
	41	9.79 589	16	9.90 346	25	0.09 654	9.89 244	11	19
	42	9.79 605	16	9.90 371	26	0.09 629	9.89 233	10	18
	43	9.79 621	15	9.90 397	26	0.09 603	9.89 223	10	17
	44	9.79 636	16	9.90 423	26	0.09 577	9.89 213	10	16
	45	9.79 652	16	9.90 449	26	0.09 551	9.89 203	10	15
	46	9.79 668	16	9.90 475	26	0.09 525	9.89 193	10	14
	47	9.79 684	15	9.90 501	26	0.09 499	9.89 183	10	13
	48	9.79 699	16	9.90 527	26	0.09 473	9.89 173	11	12
	49	9.79 715	16	9.90 553	25	0.09 447	9.89 162	10	11
	50	9.79 731	15	9.90 578	26	0.09 422	9.89 152	10	10
	51	9.79 746	16	9.90 604	26	0.09 396	9.89 142	10	9
	52	9.79 762	16	9.90 630	26	0.09 370	9.89 132	10	8
	53	9.79 778	15	9.90 656	26	0.09 344	9.89 122	10	7
	54	9.79 793	16	9.90 682	26	0.09 318	9.89 112	11	6
	55	9.79 809	16	9.90 708	26	0.09 292	9.89 101	10	5
	56	9.79 825	15	9.90 734	25	0.09 266	9.89 091	10	4
	57	9.79 840	16	9.90 759	26	0.09 241	9.89 081	10	3
	58	9.79 856	16	9.90 785	26	0.09 215	9.89 071	11	2
	59	9.79 872	15	9.90 811	26	0.09 189	9.89 060	10	1
	60	9.79 887		9.90 837		0.09 163	9.89 050		0
		L SIN	D	L TAN	CD	L COT	L COS	D	321°...141°
		L COS		L COT		L TAN	L SIN		231°... 51°

39°...219°		L SIN		L TAN		L COT	L COS		
129°...309°		L COS	D	L COT	CD	L TAN	L SIN	D	
	0	9.79 887		9.90 837		0.09 163	9.89 050		60
	1	9.79 903	16	9.90 863	26	0.09 137	9.89 040	10	59
	2	9.79 918	15	9.90 889	26	0.09 111	9.89 030	10	58
	3	9.79 934	16	9.90 914	25	0.09 086	9.89 020	10	57
	4	9.79 950	16	9.90 940	26	0.09 060	9.89 009	11	56
			15		26			10	
	5	9.79 965		9.90 966		0.09 034	9.88 999		55
	6	9.79 981	16	9.90 992	26	0.09 008	9.88 989	10	54
	7	9.79 996	15	9.91 018	26	0.08 982	9.88 978	11	53
	8	9.80 012	16	9.91 043	25	0.08 957	9.88 968	10	52
	9	9.80 027	15	9.91 069	26	0.08 931	9.88 958	10	51
			16		26			10	
	10	9.80 043		9.91 095		0.08 905	9.88 948		50
	11	9.80 058	15	9.91 121	26	0.08 879	9.88 937	11	49
	12	9.80 074	16	9.91 147	26	0.08 853	9.88 927	10	48
	13	9.80 089	15	9.91 172	25	0.08 828	9.88 917	10	47
	14	9.80 105	16	9.91 198	26	0.08 802	9.88 906	11	46
			15		26			10	
	15	9.80 120		9.91 224		0.08 776	9.88 896		45
	16	9.80 136	16	9.91 250	26	0.08 750	9.88 886	10	44
	17	9.80 151	15	9.91 276	26	0.08 724	9.88 875	11	43
	18	9.80 166	15	9.91 301	25	0.08 699	9.88 865	10	42
	19	9.80 182	16	9.91 327	26	0.08 673	9.88 855	10	41
			15		26			11	
	20	9.80 197		9.91 353		0.08 647	9.88 844		40
	21	9.80 213	16	9.91 379	26	0.08 621	9.88 834	10	39
	22	9.80 228	15	9.91 404	25	0.08 596	9.88 824	10	38
	23	9.80 244	16	9.91 430	26	0.08 570	9.88 813	11	37
	24	9.80 259	15	9.91 456	26	0.08 544	9.88 803	10	36
			15		26			10	
	25	9.80 274		9.91 482		0.08 518	9.88 793		35
	26	9.80 290	16	9.91 507	25	0.08 493	9.88 782	11	34
	27	9.80 305	15	9.91 533	26	0.08 467	9.88 772	10	33
	28	9.80 320	15	9.91 559	26	0.08 441	9.88 761	11	32
	29	9.80 336	16	9.91 585	26	0.08 415	9.88 751	10	31
			15		25			10	
	30	9.80 351		9.91 610		0.08 390	9.88 741		30
	31	9.80 366	15	9.91 636	26	0.08 364	9.88 730	11	29
	32	9.80 382	16	9.91 662	26	0.08 338	9.88 720	10	28
	33	9.80 397	15	9.91 688	26	0.08 312	9.88 709	11	27
	34	9.80 412	15	9.91 713	25	0.08 287	9.88 699	10	26
			16		26			11	
	35	9.80 428		9.91 739		0.08 261	9.88 688		25
	36	9.80 443	15	9.91 765	26	0.08 235	9.88 678	10	24
	37	9.80 458	15	9.91 791	26	0.08 209	9.88 668	10	23
	38	9.80 473	15	9.91 816	25	0.08 184	9.88 657	11	22
	39	9.80 489	16	9.91 842	26	0.08 158	9.88 647	10	21
			15		26			11	
	40	9.80 504		9.91 868		0.08 132	9.88 636		20
	41	9.80 519	15	9.91 893	25	0.08 107	9.88 626	10	19
	42	9.80 534	15	9.91 919	26	0.08 081	9.88 615	11	18
	43	9.80 550	16	9.91 945	26	0.08 055	9.88 605	10	17
	44	9.80 565	15	9.91 971	26	0.08 029	9.88 594	11	16
			15		25			10	
	45	9.80 580		9.91 996		0.08 004	9.88 584		15
	46	9.80 595	15	9.92 022	26	0.07 978	9.88 573	11	14
	47	9.80 610	15	9.92 048	26	0.07 952	9.88 563	10	13
	48	9.80 625	15	9.92 073	25	0.07 927	9.88 552	11	12
	49	9.80 641	16	9.92 099	26	0.07 901	9.88 542	10	11
			15		26			11	
	50	9.80 656		9.92 125		0.07 875	9.88 531		10
	51	9.80 671	15	9.92 150	25	0.07 850	9.88 521	10	9
	52	9.80 686	15	9.92 176	26	0.07 824	9.88 510	11	8
	53	9.80 701	15	9.92 202	26	0.07 798	9.88 499	11	7
	54	9.80 716	15	9.92 227	25	0.07 773	9.88 489	10	6
			15		26			11	
	55	9.80 731		9.92 253		0.07 747	9.88 478		5
	56	9.80 746	15	9.92 279	26	0.07 721	9.88 468	10	4
	57	9.80 762	16	9.92 304	25	0.07 696	9.88 457	11	3
	58	9.80 777	15	9.92 330	26	0.07 670	9.88 447	10	2
	59	9.80 792	15	9.92 356	26	0.07 644	9.88 436	11	1
			15		25			11	
	60	9.80 807		9.92 381		0.07 619	9.88 425		0
		L SIN		L TAN		L COT	L COS		320°...140°
		L COS	D	L COT	CD	L TAN	L SIN	D	230°... 50°

40°...220°		L SIN	D	L TAN	CD	L COT	L COS	D	
130°...310°		L COS		L COT		L TAN	L SIN		
	0	9.80 807		9.92 381		0.07 619	9.88 425		60
	1	9.80 822	15	9.92 407	26	0.07 593	9.88 415	10	59
	2	9.80 837	15	9.92 433	26	0.07 567	9.88 404	11	58
	3	9.80 852	15	9.92 458	25	0.07 542	9.88 394	10	57
	4	9.80 867	15	9.92 484	26	0.07 516	9.88 383	11	56
			15		26			11	
	5	9.80 882		9.92 510		0.07 490	9.88 372		55
	6	9.80 897	15	9.92 535	25	0.07 465	9.88 362	10	54
	7	9.80 912	15	9.92 561	26	0.07 439	9.88 351	11	53
	8	9.80 927	15	9.92 587	26	0.07 413	9.88 340	11	52
	9	9.80 942	15	9.92 612	25	0.07 388	9.88 330	10	51
			15		26			11	
	10	9.80 957		9.92 638		0.07 362	9.88 319		50
	11	9.80 972	15	9.92 663	25	0.07 337	9.88 308	11	49
	12	9.80 987	15	9.92 689	26	0.07 311	9.88 298	10	48
	13	9.81 002	15	9.92 715	26	0.07 285	9.88 287	11	47
	14	9.81 017	15	9.92 740	25	0.07 260	9.88 276	11	46
			15		26			10	
	15	9.81 032		9.92 766		0.07 234	9.88 266		45
	16	9.81 047	15	9.92 792	26	0.07 208	9.88 255	11	44
	17	9.81 061	14	9.92 817	25	0.07 183	9.88 244	11	43
	18	9.81 076	15	9.92 843	26	0.07 157	9.88 234	10	42
	19	9.81 091	15	9.92 868	25	0.07 132	9.88 223	11	41
			15		26			11	
	20	9.81 106		9.92 894		0.07 106	9.88 212		40
	21	9.81 121	15	9.92 920	26	0.07 080	9.88 201	11	39
	22	9.81 136	15	9.92 945	25	0.07 055	9.88 191	10	38
	23	9.81 151	15	9.92 971	26	0.07 029	9.88 180	11	37
	24	9.81 166	15	9.92 996	25	0.07 004	9.88 169	11	36
			14		26			11	
	25	9.81 180		9.93 022		0.06 978	9.88 158		35
	26	9.81 195	15	9.93 048	26	0.06 952	9.88 148	10	34
	27	9.81 210	15	9.93 073	25	0.06 927	9.88 137	11	33
	28	9.81 225	15	9.93 099	26	0.06 901	9.88 126	11	32
	29	9.81 240	15	9.93 124	25	0.06 876	9.88 115	11	31
			14		26			10	
	30	9.81 254		9.93 150		0.06 850	9.88 105		30
	31	9.81 269	15	9.93 175	25	0.06 825	9.88 094	11	29
	32	9.81 284	15	9.93 201	26	0.06 799	9.88 083	11	28
	33	9.81 299	15	9.93 227	26	0.06 773	9.88 072	11	27
	34	9.81 314	15	9.93 252	25	0.06 748	9.88 061	11	26
			14		26			10	
	35	9.81 328		9.93 278		0.06 722	9.88 051		25
	36	9.81 343	15	9.93 303	25	0.06 697	9.88 040	11	24
	37	9.81 358	15	9.93 329	26	0.06 671	9.88 029	11	23
	38	9.81 372	14	9.93 354	25	0.06 646	9.88 018	11	22
	39	9.81 387	15	9.93 380	26	0.06 620	9.88 007	11	21
			15		26			11	
	40	9.81 402		9.93 406		0.06 594	9.87 996		20
	41	9.81 417	15	9.93 431	25	0.06 569	9.87 985	11	19
	42	9.81 431	14	9.93 457	26	0.06 543	9.87 975	10	18
	43	9.81 446	15	9.93 482	25	0.06 518	9.87 964	11	17
	44	9.81 461	15	9.93 508	26	0.06 492	9.87 953	11	16
			14		25			11	
	45	9.81 475		9.93 533		0.06 467	9.87 942		15
	46	9.81 490	15	9.93 559	26	0.06 441	9.87 931	11	14
	47	9.81 505	15	9.93 584	25	0.06 416	9.87 920	11	13
	48	9.81 519	14	9.93 610	26	0.06 390	9.87 909	11	12
	49	9.81 534	15	9.93 636	26	0.06 364	9.87 898	11	11
			15		25			11	
	50	9.81 549		9.93 661		0.06 339	9.87 887		10
	51	9.81 563	14	9.93 687	26	0.06 313	9.87 877	10	9
	52	9.81 578	15	9.93 712	25	0.06 288	9.87 866	11	8
	53	9.81 592	14	9.93 738	26	0.06 262	9.87 855	11	7
	54	9.81 607	15	9.93 763	25	0.06 237	9.87 844	11	6
			15		26			11	
	55	9.81 622		9.93 789		0.06 211	9.87 833		5
	56	9.81 636	14	9.93 814	25	0.06 186	9.87 822	11	4
	57	9.81 651	15	9.93 840	26	0.06 160	9.87 811	11	3
	58	9.81 665	14	9.93 865	25	0.06 135	9.87 800	11	2
	59	9.81 680	15	9.93 891	26	0.06 109	9.87 789	11	1
			14		25			11	
	60	9.81 694		9.93 916		0.06 084	9.87 778		0
		L SIN	D	L TAN	CD	L COT	L COS	D	319°...139°
		L COS		L COT		L TAN	L SIN		229°... 49°

41° ... 221°		L SIN		L TAN		L COT	L COS		
131° ... 311°		L COS	D	L COT	CD	L TAN	L SIN	D	
	0	9.81 694	15	9.93 916	26	0.06 084	9.87 778	11	60
	1	9.81 709	14	9.93 942	25	0.06 058	9.87 787	11	59
	2	9.81 723	15	9.93 967	26	0.06 033	9.87 756	11	58
	3	9.81 738	14	9.93 993	25	0.06 007	9.87 745	11	57
	4	9.81 752	15	9.94 018	26	0.05 982	9.87 734	11	56
	5	9.81 767	14	9.94 044	25	0.05 956	9.87 723	11	55
	6	9.81 781	15	9.94 069	26	0.05 931	9.87 712	11	54
	7	9.81 796	14	9.94 095	25	0.05 905	9.87 701	11	53
	8	9.81 810	15	9.94 120	26	0.05 880	9.87 690	11	52
	9	9.81 825	14	9.94 146	25	0.05 854	9.87 679	11	51
	10	9.81 839	15	9.94 171	26	0.05 829	9.87 668	11	50
	11	9.81 854	14	9.94 197	25	0.05 803	9.87 657	11	49
	12	9.81 868	14	9.94 222	26	0.05 778	9.87 646	11	48
	13	9.81 882	15	9.94 248	25	0.05 752	9.87 635	11	47
	14	9.81 897	14	9.94 273	26	0.05 727	9.87 624	11	46
	15	9.81 911	15	9.94 299	25	0.05 701	9.87 613	12	45
	16	9.81 926	14	9.94 324	26	0.05 676	9.87 601	11	44
	17	9.81 940	15	9.94 350	25	0.05 650	9.87 590	11	43
	18	9.81 955	14	9.94 375	26	0.04 625	9.87 579	11	42
	19	9.81 969	14	9.94 401	25	0.05 599	9.87 568	11	41
	20	9.81 983	15	9.94 426	26	0.05 574	9.87 557	11	40
	21	9.81 998	14	9.94 452	25	0.05 548	9.87 546	11	39
	22	9.82 012	14	9.94 477	26	0.05 523	9.87 535	11	38
	23	9.82 026	15	9.94 503	25	0.05 497	9.87 524	11	37
	24	9.82 041	14	9.94 528	26	0.05 472	9.87 513	12	36
	25	9.82 055	14	9.94 554	25	0.05 446	9.87 501	11	35
	26	9.82 069	15	9.94 579	25	0.05 421	9.87 490	11	34
	27	9.82 084	14	9.94 604	26	0.05 396	9.87 479	11	33
	28	9.82 098	14	9.94 630	25	0.05 370	9.87 468	11	32
	29	9.82 112	14	9.94 655	26	0.05 345	9.87 457	11	31
	30	9.82 126	15	9.94 681	25	0.05 319	9.87 446	12	30
	31	9.82 141	14	9.94 706	26	0.05 294	9.87 434	11	29
	32	9.82 155	14	9.94 732	25	0.05 268	9.87 423	11	28
	33	9.82 169	15	9.94 757	26	0.05 243	9.87 412	11	27
	34	9.82 184	14	9.94 783	25	0.05 217	9.87 401	11	26
	35	9.82 198	14	9.94 808	26	0.05 192	9.87 390	12	25
	36	9.82 212	14	9.94 834	25	0.05 166	9.87 378	11	24
	37	9.82 226	14	9.94 859	25	0.05 141	9.87 367	11	23
	38	9.82 240	15	9.94 884	26	0.05 116	9.87 356	11	22
	39	9.82 255	14	9.94 910	25	0.05 090	9.87 345	11	21
	40	9.82 269	14	9.94 935	26	0.05 065	9.87 324	12	20
	41	9.82 283	14	9.94 961	25	0.05 039	9.87 322	11	19
	42	9.82 297	14	9.94 986	26	0.05 014	9.87 311	11	18
	43	9.82 311	15	9.95 012	25	0.04 988	9.87 300	11	17
	44	9.82 326	14	9.95 037	25	0.04 963	9.87 288	12	16
	45	9.82 340	14	9.95 062	26	0.04 938	9.87 277	11	15
	46	9.82 354	14	9.95 088	25	0.04 912	9.87 266	11	14
	47	9.82 368	14	9.95 113	26	0.04 887	9.87 255	11	13
	48	9.82 382	14	9.95 139	25	0.04 861	9.87 243	12	12
	49	9.82 396	14	9.95 164	26	0.04 836	9.87 232	11	11
	50	9.82 410	14	9.95 190	25	0.04 810	9.87 221	12	10
	51	9.82 424	15	9.95 215	25	0.04 785	9.87 209	11	9
	52	9.82 439	14	9.95 240	26	0.04 760	9.87 198	11	8
	53	9.82 453	14	9.95 266	25	0.04 734	9.87 187	12	7
	54	9.82 467	14	9.95 291	26	0.04 709	9.87 175	11	6
	55	9.82 481	14	9.95 317	25	0.04 683	9.87 164	11	5
	56	9.82 495	14	9.95 342	26	0.04 658	9.87 153	12	4
	57	9.82 509	14	9.95 368	25	0.04 632	0.87 141	11	3
	58	9.82 523	14	9.95 393	25	0.04 607	9.87 130	11	2
	59	9.82 537	14	9.95 418	25	0.04 582	9.87 119	11	1
	60	9.82 551		9.95 444	26	0.04 556	9.87 107	12	0
		L SIN	D	L TAN	CD	L COT	L COS	D	318° ... 138°
		L COS		L COT		L TAN	L SIN		228° ... 48°

42°...222°		L SIN		L TAN		L COT	L COS		
132°...312°		L COS	D	L COT	CD	L TAN	L SIN	D	
	0	9.82 551	14	9.95 444	25	0.04 556	9.87 107	11	60
	1	9.82 565	14	9.95 469	26	0.04 531	9.87 096	11	59
	2	9.82 579	14	9.95 495	25	0.04 505	9.87 085	12	58
	3	9.82 593	14	9.95 520	25	0.04 480	9.87 073	11	57
	4	9.82 607	14	9.95 545	25	0.04 455	9.87 062	11	56
			14		26			12	
	5	9.82 621	14	9.95 571	25	0.04 429	9.87 050	11	55
	6	9.82 635	14	9.95 596	26	0.04 404	9.87 039	11	54
	7	9.82 649	14	9.95 622	25	0.04 378	9.87 028	12	53
	8	9.82 663	14	9.95 647	25	0.04 353	9.87 016	12	52
	9	9.82 677	14	9.95 672	25	0.04 328	9.87 005	11	51
			14		26			12	
	10	9.82 691	14	9.95 698	25	0.04 302	9.86 993	11	50
	11	9.82 705	14	9.95 723	25	0.04 277	9.86 982	12	49
	12	9.82 719	14	9.95 748	26	0.04 252	9.86 970	11	48
	13	9.82 733	14	9.95 774	25	0.04 226	9.86 959	12	47
	14	9.82 747	14	9.95 799	25	0.04 201	9.86 947	11	46
			14		26				
	15	9.82 761	14	9.95 825	25	0.04 175	9.86 936	12	45
	16	9.82 775	13	9.95 850	25	0.04 150	9.86 924	11	44
	17	9.82 788	14	9.95 875	26	0.04 125	9.86 913	11	43
	18	9.82 802	14	9.95 901	25	0.04 099	9.86 902	11	42
	19	9.82 816	14	9.95 926	25	0.04 074	9.86 890	12	41
			14		26			11	
	20	9.82 830	14	9.95 952	25	0.04 048	9.86 879	12	40
	21	9.82 844	14	9.95 977	25	0.04 023	9.86 867	12	39
	22	9.82 858	14	9.96 002	26	0.03 998	9.86 855	12	38
	23	9.82 872	13	9.96 028	26	0.03 972	9.86 844	11	37
	24	9.82 885	14	9.96 053	25	0.03 947	9.86 832	12	36
			14		25			11	
	25	9.82 899	14	9.96 078	26	0.03 922	9.86 821	12	35
	26	9.82 913	14	9.96 104	25	0.03 896	9.86 809	12	34
	27	9.82 927	14	9.96 129	26	0.03 871	9.86 798	11	33
	28	9.82 941	14	9.96 155	26	0.03 845	9.86 786	12	32
	29	9.82 955	14	9.96 180	25	0.03 820	9.86 775	11	31
			13		25			12	
	30	9.82 968	14	9.96 205	26	0.03 795	9.86 763	11	30
	31	9.82 982	14	9.96 231	25	0.03 769	9.86 752	12	29
	32	9.82 996	14	9.96 256	25	0.03 744	9.86 740	12	28
	33	9.83 010	14	9.96 281	25	0.03 719	9.86 728	12	27
	34	9.83 023	13	9.96 307	26	0.03 693	9.86 717	11	26
			14		25			12	
	35	9.83 037	14	9.96 332	25	0.03 668	9.86 705	11	25
	36	9.83 051	14	9.96 357	26	0.03 643	9.86 694	12	24
	37	9.83 065	13	9.96 383	25	0.03 617	9.86 682	12	23
	38	9.83 078	14	9.96 408	25	0.03 592	9.86 670	12	22
	39	9.83 092	14	9.96 433	25	0.03 567	9.86 659	11	22
			14		26			12	21
	40	9.83 106	14	9.96 459	25	0.03 541	9.86 647	12	20
	41	9.83 120	13	9.96 484	26	0.03 516	9.86 635	11	19
	42	9.83 133	14	9.96 510	25	0.03 490	9.86 624	12	18
	43	9.83 147	14	9.96 535	25	0.03 465	9.86 612	12	17
	44	9.83 161	13	9.96 560	25	0.03 440	9.86 600	12	16
			13		26			11	
	45	9.83 174	14	9.96 586	25	0.03 414	9.86 589	12	15
	46	9.83 188	14	9.96 611	25	0.03 389	9.86 577	12	14
	47	9.83 202	13	9.96 636	26	0.03 364	9.86 565	12	13
	48	9.83 215	14	9.96 662	25	0.03 338	9.86 554	11	12
	49	9.83 229	13	9.96 687	25	0.03 313	9.86 542	12	11
			13		25			12	
	50	9.83 242	14	9.96 712	26	0.03 288	9.86 530	12	10
	51	9.83 256	14	9.96 738	25	0.03 262	9.86 518	11	9
	52	9.83 270	13	9.96 763	25	0.03 237	9.86 507	12	8
	53	9.83 283	14	9.96 788	26	0.03 212	9.86 495	12	7
	54	9.83 297	13	9.96 814	25	0.03 186	9.86 483	12	6
			13		25			11	
	55	9.83 310	14	9.96 839	25	0.03 161	9.86 472	12	5
	56	9.83 324	14	9.96 864	26	0.03 136	9.86 460	12	4
	57	9.83 338	13	9.96 890	25	0.03 110	9.86 448	12	3
	58	9.83 351	14	9.96 915	25	0.03 085	9.86 436	12	2
	59	9.83 365	13	9.96 940	26	0.03 060	9.86 425	11	1
			13		25			12	
	60	9.83 378		9.96 966		0.03 034	9.86.413		0
		L SIN	D	L TAN	CD	L COT	L COS	D	317°...137°
		L COS		L COT		L TAN	L SIN		227°... 47°

43° ... 223°		L SIN		L TAN		L COT	L COS		
133° ... 313°		L COS	D	L COT	CD	L TAN	L SIN	D	
	0	9.83 378	14	9.96 966	25	0.03 034	9.86 413	12	60
	1	9.83 392	13	9.96 991	25	0.03 009	9.86 401	12	59
	2	9.83 405	14	9.97 016	26	0.02 984	9.86 389	12	58
	3	9.83 419	13	9.97 042	25	0.02 958	9.86 377	11	57
	4	9.83 432	14	9.97 067	25	0.02 933	9.86 366	12	56
	5	9.83 446	13	9.97 092	26	0.02 908	9.86 354	12	55
	6	9.83 459	14	9.97 118	25	0.02 882	9.86 342	12	54
	7	9.83 473	13	9.97 143	25	0.02 857	9.86 330	12	53
	8	9.83 486	14	9.97 168	25	0.02 832	9.86 318	12	52
	9	9.93 500	13	9.97 193	26	0.02 807	9.86 306	11	51
	10	9.83 513	14	9.97 219	25	0.02 781	9.86 295	12	50
	11	9.83 527	13	9.97 244	25	0.02 756	9.86 283	12	49
	12	9.83 540	14	9.97 269	26	0.02 731	9.86 271	12	48
	13	9.83 554	13	9.97 295	25	0.02 705	9.86 259	12	47
	14	9.83 567	14	9.95 320	25	0.02 680	9.86 247	12	46
	15	9.83 581	13	9.97 345	26	0.02 655	9.86 235	12	45
	16	9.83 594	14	9.97 371	25	0.02 620	9.86 223	12	44
	17	9.83 608	13	9.97 396	25	0.02 601	9.86 211	11	43
	18	9.83 621	13	9.97 421	26	0.02 579	9.86 200	12	42
	19	9.83 634	14	9.97 447	25	0.02 553	9.86 188	12	41
	20	9.83 648	13	9.97 472	25	0.02 528	9.86 176	12	40
	21	9.83 661	13	9.97 497	26	0.02 503	9.86 164	12	39
	22	9.83 674	14	9.97 523	25	0.02 477	9.86 152	12	38
	23	9.83 688	13	9.97 548	25	0.02 452	9.86 140	12	37
	24	9.83 701	14	9.97 573	25	0.02 427	9.86 128	12	36
	25	9.83 715	13	9.97 598	26	0.02 402	9.86 116	12	35
	26	9.83 728	13	9.97 624	25	0.02 376	9.86 104	12	34
	27	9.83 741	14	9.97 649	25	0.02 351	9.86 092	12	33
	28	9.83 755	13	9.97 674	26	0.02 326	9.86 080	12	32
	29	9.83 768	13	9.97 700	25	0.02 300	9.86 068	12	31
	30	9.83 781	14	9.97 725	25	0.02 275	9.86 056	12	30
	31	9.83 795	13	9.97 750	26	0.02 250	9.86 044	12	29
	32	9.83 808	13	9.97 776	25	0.02 224	9.86 032	12	28
	33	9.83 821	13	9.97 801	25	0.02 190	9.86 020	12	27
	34	9.83 834	14	9.97 826	25	0.02 174	9.86 008	12	26
	35	9.83 848	13	9.97 861	26	0.02 149	9.85 996	12	25
	36	9.83 861	13	9.97 877	25	0.02 123	9.85 984	12	24
	37	9.83 874	13	9.97 902	25	0.02 098	9.85 972	12	23
	38	9.83 887	14	9.97 927	26	0.02 073	9.85 960	12	22
	39	9.83 901	13	9.97 953	25	0.02 047	9.85 948	12	21
	40	9.83 914	13	9.97 978	25	0.02 022	9.85 936	12	20
	41	9.83 927	13	9.98 003	26	0.01 997	9.85 924	12	19
	42	9.83 940	14	9.98 029	25	0.01 971	9.85 912	12	18
	43	9.83 954	13	9.98 054	25	0.01 946	9.85 900	12	17
	44	9.83 967	13	9.98 079	25	0.01 921	9.85 888	12	16
	45	9.83 980	13	9.98 104	26	0.01 896	9.85 876	12	15
	46	9.83 993	13	9.98 130	25	0.01 870	9.85 864	13	14
	47	9.84 006	14	9.98 155	25	0.01 845	9.85 851	12	13
	48	9.84 020	13	9.98 180	25	0.01 820	9.85 839	12	12
	49	9.84 033	13	9.98 206	26	0.01 794	9.85 827	12	11
	50	9.84 046	13	9.98 231	25	0.01 769	9.85 815	12	10
	51	9.84 059	13	9.98 256	25	0.01 744	9.85 803	12	9
	52	9.84 072	13	9.98 281	26	0.01 719	9.85 791	12	8
	53	9.83 085	13	9.98 307	25	0.01 693	9.85 779	13	7
	54	9.84 098	14	9.98 332	25	0.01 668	9.85 766	12	6
	55	9.84 112	13	9.98 357	26	0.01 643	9.85 754	12	5
	56	9.84 125	13	9.98 383	25	0.01 617	9.85 742	12	4
	57	9.84 138	13	9.98 408	25	0.01 592	9.85 730	12	3
	58	9.84 151	13	9.98 433	25	0.01 567	9.85 718	12	2
	59	9.84 164	13	9.98 458	26	0.01 542	9.85 706	13	1
	60	9.84 177		9.98 484		0.01 516	9.85 693		0
		L SIN	D	L TAN	CD	L COT	L COS	D	316° ... 136°
		L COS		L COT		L TAN	L SIN		226° ... 46°

44°...224°		L SIN	D	L TAN	CD	L COT	L COS	D	
134°...314°		L COS		L COT		L TAN	L SIN		
	0	9.84 177	13	9.98 484	25	0.01 516	9.85 693	12	60
	1	9.84 190		9.98 509	25	0.01 491	9.85 681	12	59
	2	9.84 203		9.98 534	26	0.01 466	9.85 669	12	58
	3	9.84 216		9.98 560	25	0.01 440	9.85 657	12	57
	4	9.84 229		9.98 585	25	0.01 415	9.85 645	13	56
	5	9.84 242	13	9.98 610	25	0.01 390	9.85 632	12	55
	6	9.84 255		9.98 635	26	0.01 365	9.85 620	12	54
	7	9.84 269		9.98 661	25	0.01 339	9.85 608	12	53
	8	9.84 282		9.98 686	25	0.01 314	9.85 598	13	52
	9	9.84 295		9.98 711	26	0.01 289	9.85 583	12	51
	10	9.84 308	13	9.98 737	25	0.01 263	9.85 571	12	50
	11	9.84 321		9.98 762	25	0.01 238	9.85 559	12	49
	12	9.84 334		9.98 787	25	0.01 213	9.85 547	13	48
	13	9.84 347		9.98 812	26	0.01 188	9.85 534	12	47
	14	9.84 360		9.98 838	25	0.01 162	9.85 522	12	46
	15	9.84 373	12	9.98 863	25	0.01 137	9.85 510	13	45
	16	9.84 385		9.98 888	25	0.01 112	9.85 497	12	44
	17	9.84 398		9.98 913	26	0.01 087	9.85 485	12	43
	18	9.84 411		9.98 939	25	0.01 061	9.85 473	13	42
	19	9.84 424		9.98 964	25	0.01 036	9.85 460	12	41
	20	9.84 437	13	9.98 989	26	0.01 011	9.85 448	12	40
	21	9.84 450		9.99 015	25	0.00 985	9.85 436	13	39
	22	9.84 463		9.99 040	25	0.00 960	9.85 423	12	38
	23	9.84 476		9.99 065	25	0.00 935	9.85 411	12	37
	24	9.84 489		9.99 090	26	0.00 910	9.85 399	13	36
	25	9.84 502	13	9.99 116	25	0.00 884	9.85 386	12	35
	26	9.84 515		9.99 141	25	0.00 859	9.85 374	13	34
	27	9.84 528		9.99 166	25	0.00 834	9.85 361	12	33
	28	9.84 540		9.99 191	26	0.00 809	9.85 349	12	32
	29	9.84 553		9.99 217	25	0.00 783	9.85 337	13	31
	30	9.84 566	13	9.99 242	25	0.00 758	9.85 324	12	30
	31	9.84 579		9.99 267	26	0.00 733	9.85 312	13	29
	32	9.84 592		9.99 293	25	0.00 707	9.85 299	12	28
	33	9.84 605		9.99 318	25	0.00 682	9.85 287	13	27
	34	9.84 618		9.99 343	25	0.00 657	9.85 274	12	26
	35	9.84 630	13	9.99 368	26	0.00 632	9.85 262	12	25
	36	9.84 643		9.99 394	25	0.00 606	9.85 250	13	24
	37	9.84 656		9.99 419	25	0.00 581	9.85 237	12	23
	38	9.84 669		9.99 444	25	0.00 556	9.85 225	13	22
	39	9.84 682		9.99 469	26	0.00 531	9.85 212	12	21
	40	9.84 694	13	9.99 495	25	0.00 505	9.85 200	13	20
	41	9.84 707		9.99 520	25	0.00 480	9.85 187	12	19
	42	9.84 720		9.99 545	25	0.00 455	9.85 175	13	18
	43	9.84 733		9.99 570	26	0.00 430	9.85 162	12	17
	44	9.84 745		9.99 596	25	0.00 404	9.85 150	13	16
	45	9.84 758	13	9.99 621	25	0.00 379	9.85 137	12	15
	46	9.84 771		9.99 646	26	0.00 354	9.85 125	13	14
	47	9.84 784		9.99 672	25	0.00 328	9.85 112	12	13
	48	9.84 796		9.99 697	25	0.00 303	9.85 100	12	12
	49	9.84 809		9.99 722	25	0.00 278	9.85 087	13	11
	50	9.84 822	13	9.99 747	26	0.00 253	9.85 074	12	10
	51	9.84 835		9.99 773	25	0.00 227	9.85 062	13	9
	52	9.84 847		9.99 798	25	0.00 202	9.85 049	12	8
	53	9.84 860		9.99 823	25	0.00 177	9.85 037	13	7
	54	9.84 873		9.99 848	26	0.00 152	9.85 024	12	6
	55	9.84 885	13	9.99 874	25	0.00 126	9.85 012	13	5
	56	9.84 898		9.99 899	25	0.00 101	9.84 999	13	4
	57	9.84 911		9.99 924	25	0.00 076	9.84 986	12	3
	58	9.84 923		9.99 949	26	0.00 051	9.84 974	13	2
	59	9.84 936		9.99 975	25	0.00 025	9.84 961	12	1
	60	9.84 949		0.00 000		0.00 000	9.84 949		0
		L SIN	D	L TAN	CD	L COT	L COS	D	
		L COS		L COT		L TAN	L SIN		
									315°...135°
									225°...45°

APPENDIX B

**DEAD-RECKONING
ALTITUDE AND AZIMUTH
TABLE**

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

	0°00'		0°30'		1°00'		1°30'		2°00'		
	A	B	A	B	A	B	A	B	A	B	
0	-----0.0		205916.....1.7		175814.....6.6		158208.....14.9		145718.....26.5		30
1	383730.....0.0		205198.....1.7		175454.....6.7		157967.....15.1		145538.....26.7		29
	353627.....0.0		204492.....1.8		175097.....6.8		157728.....15.2		145358.....26.9		
	336018.....0.0		203797.....1.8		174742.....7.0		157490.....15.4		145179.....27.1		
2	323524.....0.0		203113.....1.9		174391.....7.1		157254.....15.6		145000.....27.3		28
3	313833.....0.0		202440.....1.9		174042.....7.2		157019.....15.7		144823.....27.6		27
	305915.....0.0		201777.....2.0		173696.....7.3		156784.....15.9		144646.....27.8		
	299221.....0.0		201124.....2.1		173352.....7.4		156552.....16.1		144470.....28.0		
4	293421.....0.0		200480.....2.1		173012.....7.5		156320.....16.2		144295.....28.3		26
5	288306.....0.0		199846.....2.2		172674.....7.6		156090.....16.4		144120.....28.5		25
	283730.....0.0		199221.....2.3		172339.....7.8		155861.....16.6		143946.....28.7		
	279591.....0.1		198605.....2.3		172006.....7.9		155633.....16.8		143773.....28.9		
6	275812.....0.1		197998.....2.4		171676.....8.0		155406.....16.9		143600.....29.2		24
7	272336.....0.1		197399.....2.4		171348.....8.1		155180.....17.1		143428.....29.4		23
	269118.....0.1		196808.....2.5		171023.....8.2		154956.....17.3		143257.....29.6		
	266121.....0.1		196225.....2.6		170700.....8.4		154733.....17.5		143086.....29.9		
8	263318.....0.1		195650.....2.7		170379.....8.5		154511.....17.6		142916.....30.1		22
9	260685.....0.1		195082.....2.7		170061.....8.6		154290.....17.8		142747.....30.4		21
	258203.....0.1		194522.....2.8		169745.....8.7		154070.....18.0		142579.....30.6		
	255855.....0.2		193969.....2.9		169432.....8.9		153851.....18.2		142411.....30.8		
10	253627.....0.2		193422.....2.9		169121.....9.0		153633.....18.4		142243.....31.1		20
11	251508.....0.2		192883.....3.0		168811.....9.1		153417.....18.6		142077.....31.3		19
	249488.....0.2		192350.....3.1		168505.....9.3		153201.....18.7		141911.....31.5		
	247558.....0.2		191824.....3.2		168200.....9.4		152987.....18.9		141745.....31.8		
12	245709.....0.3		191303.....3.2		167897.....9.5		152774.....19.1		141581.....32.0		18
13	243936.....0.3		190790.....3.3		167597.....9.7		152561.....19.3		141417.....32.3		17
	242233.....0.3		190282.....3.4		167298.....9.8		152350.....19.5		141253.....32.5		
	240594.....0.3		189780.....3.5		167002.....9.9		152140.....19.7		141090.....32.8		
14	239015.....0.4		189283.....3.6		166708.....10.1		151931.....19.9		140928.....33.0		16
15	237491.....0.4		188793.....3.6		166415.....10.2		151722.....20.1		140766.....33.3		15
	236018.....0.4		188307.....3.7		166125.....10.3		151515.....20.3		140605.....33.5		
	234594.....0.4		187827.....3.8		165836.....10.5		151309.....20.5		140445.....33.7		
16	233215.....0.5		187353.....3.9		165550.....10.6		151104.....20.6		140285.....34.0		14
17	231879.....0.5		186883.....4.0		165265.....10.8		150899.....20.8		140125.....34.2		13
	230583.....0.5		186419.....4.1		164982.....10.9		150696.....21.0		139967.....34.5		
	229324.....0.6		185959.....4.1		164701.....11.0		150494.....21.2		139809.....34.7		
18	228100.....0.6		185505.....4.2		164422.....11.2		150292.....21.4		139651.....35.0		12
19	226910.....0.6		185055.....4.3		164144.....11.3		150092.....21.6		139494.....35.3		11
	225752.....0.7		184609.....4.4		163868.....11.5		149892.....21.8		139338.....35.5		
	224624.....0.7		184168.....4.5		163594.....11.6		149693.....22.0		139182.....35.8		
20	223525.....0.7		183732.....4.6		163322.....11.8		149495.....22.2		139027.....36.0		10
21	222452.....0.8		183300.....4.7		163052.....11.9		149299.....22.4		138872.....36.3		9
	221406.....0.8		182872.....4.8		162783.....12.1		149103.....22.6		138718.....36.5		
	220384.....0.9		182448.....4.9		162516.....12.2		148907.....22.9		138564.....36.8		
22	219385.....0.9		182029.....5.0		162250.....12.4		148713.....23.1		138411.....37.1		8
23	218409.....0.9		181613.....5.1		161986.....12.5		148520.....23.3		138258.....37.3		7
	217455.....1.0		181201.....5.2		161724.....12.7		148327.....23.5		138106.....37.6		
	216521.....1.0		180794.....5.3		161463.....12.8		148135.....23.7		137955.....37.9		
24	215607.....1.1		180390.....5.4		161204.....13.0		147945.....23.9		137804.....38.1		6
25	214711.....1.1		179990.....5.5		160946.....13.1		147755.....24.1		137653.....38.4		5
	213834.....1.1		179593.....5.6		160690.....13.3		147566.....24.3		137504.....38.6		
	212974.....1.2		179200.....5.7		160435.....13.4		147377.....24.5		137354.....38.9		
26	212130.....1.2		178810.....5.8		160182.....13.6		147190.....24.7		137205.....39.2		4
27	211303.....1.3		178424.....5.9		159930.....13.8		147003.....24.9		137057.....39.4		3
	210491.....1.3		178042.....6.0		159680.....13.9		146817.....25.2		136909.....39.7		
	209695.....1.4		177663.....6.1		159431.....14.1		146632.....25.4		136761.....40.0		
28	208912.....1.4		177287.....6.2		159184.....14.2		146448.....25.6		136615.....40.3		2
29	208143.....1.5		176914.....6.3		158938.....14.4		146264.....25.8		136468.....40.5		1
	207388.....1.5		176544.....6.4		158693.....14.6		146081.....26.0		136322.....40.8		
	206646.....1.6		176178.....6.5		158450.....14.7		145899.....26.2		136177.....41.1		
30	205916.....1.7		175814.....6.6		158208.....14.9		145718.....26.5		136032.....41.4		0
	A	B	A	B	A	B	A	B	A	B	
	179°30'		179°00'		178°30'		178°00'		177°30'		

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	2°30'		3°00'		3°30'		4°00'		4°30'		
	A	B	A	B	A	B	A	B	A	B	
0	136032....41.4		128120....59.6		121432....81.1		115641....105.9		110536....134.1		30
1	135888....41.6		128000....59.9		121329....81.5		115551....106.4		110455....134.6		29
	135744....41.9		127880....60.2		121226....81.9		115461....106.8		110375....135.1		
	135600....42.2		127760....60.6		121124....82.2		115371....107.3		110296....135.6		
2	135457....42.5		127640....60.9		121021....82.6		115282....107.7		110216....136.1		28
3	135315....42.7		127521....61.2		120919....83.0		115192....108.1		110136....136.6		27
	135173....43.0		127403....61.6		120817....83.4		115103....108.6		110057....137.1		
	135031....43.3		127284....61.9		120715....83.8		115014....109.0		109977....137.6		
4	134890....43.6		127166....62.2		120614....84.2		114925....109.5		109898....138.1		26
5	134749....43.9		127049....62.6		120513....84.6		114836....109.9		109819....138.6		25
	134609....44.2		126931....62.9		120412....85.0		114747....110.4		109740....139.1		
	134469....44.4		126814....63.3		120311....85.4		114659....110.8		109662....139.6		
6	134330....44.7		126697....63.6		120211....85.8		114571....111.3		109583....140.1		24
7	134191....45.0		126581....63.9		120110....86.2		114483....111.7		109505....140.6		23
	134052....45.3		126465....64.3		120010....86.6		114395....112.2		109426....141.1		
	133914....45.6		126349....64.6		119910....87.0		114307....112.7		109348....141.7		
8	133777....45.9		126233....65.0		119811....87.4		114220....113.1		109270....142.2		22
9	133640....46.2		126118....65.3		119711....87.8		114133....113.6		109192....142.7		21
	133503....46.5		126003....65.7		119612....88.2		114045....114.0		109115....143.2		
	133367....46.8		125888....66.0		119513....88.6		113958....114.5		109037....143.7		
10	133231....47.1		125774....66.4		119415....89.0		113872....114.9		108960....144.2		20
11	133096....47.4		125660....66.7		119316....89.4		113785....115.4		108882....144.7		19
	132961....47.6		125546....67.1		119218....89.8		113699....115.9		108805....145.2		
	132826....47.9		125433....67.4		119120....90.2		113612....116.3		108728....145.8		
12	132692....48.2		125320....67.8		119022....90.6		113526....116.8		108651....146.3		18
13	132558....48.5		125207....68.1		118925....91.0		113440....117.3		108574....146.8		17
	132425....48.8		125094....68.5		118827....91.4		113354....117.7		108498....147.3		
	132292....49.1		124982....68.8		118730....91.8		113269....118.2		108421....147.8		
14	132159....49.4		124870....69.2		118633....92.3		113183....118.7		108345....148.4		16
15	132027....49.7		124759....69.6		118537....92.7		113098....119.1		108269....148.9		15
	131896....50.0		124647....69.9		118440....93.1		113013....119.6		108193....149.4		
	131764....50.3		124536....70.3		118344....93.5		112928....120.1		108117....149.9		
16	131633....50.7		124425....70.6		118248....93.9		112843....120.5		108041....150.5		14
17	131503....51.0		124315....71.0		118152....94.3		112759....121.0		107965....151.0		13
	131373....51.3		124204....71.3		118056....94.7		112674....121.5		107890....151.5		
	131243....51.6		124095....71.7		117961....95.2		112590....121.9		107814....152.1		
18	131114....51.9		123985....72.1		117866....95.6		112506....122.4		107739....152.6		12
19	130985....52.2		123875....72.4		117771....96.0		112422....122.9		107664....153.1		11
	130856....52.5		123766....72.8		117676....96.4		112338....123.4		107589....153.6		
	130728....52.8		123657....73.2		117581....96.9		112255....123.9		107514....154.2		
20	130600....53.1		123549....73.5		117487....97.3		112171....124.3		107439....154.7		10
21	130473....53.4		123441....73.9		117393....97.7		112088....124.8		107364....155.2		9
	130346....53.7		123332....74.3		117299....98.1		112005....125.3		107290....155.8		
	130219....54.1		123225....74.6		117205....98.5		111922....125.8		107216....156.3		
22	130093....54.4		123117....75.0		117112....99.0		111839....126.2		107141....156.9		8
23	129967....54.7		123010....75.4		117018....99.4		111757....126.7		107067....157.4		7
	129841....55.0		122903....75.8		116925....99.8		111674....127.2		106993....157.9		
	129716....55.3		122796....76.1		116832....100.3		111592....127.7		106919....158.5		
24	129591....55.7		122690....76.5		116739....100.7		111510....128.2		106846....159.0		6
25	129466....56.0		122584....76.9		116647....101.1		111428....128.7		106772....159.6		5
	129342....56.3		122478....77.3		116554....101.6		111346....129.2		106698....160.1		
	129218....56.6		122372....77.6		116462....102.0		111264....129.7		106625....160.6		
26	129095....56.9		122267....78.0		116370....102.4		111183....130.1		106552....161.2		4
27	128972....57.3		122161....78.4		116278....102.9		111101....130.6		106479....161.7		3
	128849....57.6		122057....78.8		116187....103.3		111020....131.1		106406....162.3		
	128727....57.9		121952....79.2		116096....103.7		110939....131.6		106333....162.8		
28	128605....58.2		121848....79.5		116004....104.2		110858....132.1		106260....163.4		2
29	128483....58.6		121743....79.9		115913....104.6		110777....132.6		106187....163.9		1
	128362....58.9		121639....80.3		115823....105.0		110696....133.1		106115....164.5		
	128240....59.2		121536....80.7		115732....105.5		110616....133.6		106043....165.0		
30	128120....59.6		121432....81.1		115641....105.9		110536....134.1		105970....165.6		0
	A	B	A	B	A	B	A	B	A	B	
	177°00'		176°30'		176°00'		175°30'		175°00'		

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

	5°00'		5°30'		6°00'		6°30'		7°00'		
	A	B	A	B	A	B	A	B	A	B	
0	105970...165.6		101843...200.4		98076...239		94614...280		91411...325		30
1	105898...166.1		101777...201.0		98017...239		94559...281		91359...326		29
	105826...166.7		101712...201.6		97957...240		94503...281		91308...326		
	105754...167.2		101646...202.2		97897...241		94448...282		91257...327		
2	105683...167.8		101581...202.8		97837...241		94393...283		91205...328		28
3	105611...168.4		101516...203.5		97777...242		94338...284		91154...329		27
	105539...168.9		101451...204.1		97717...243		94283...284		91103...330		
	105468...169.4		101386...204.7		97658...243		94228...285		91052...330		
4	105397...170.0		101321...205.3		97598...244		94173...286		91001...331		26
5	105325...170.6		101256...205.9		97539...245		94118...287		90950...332		25
	105254...171.1		101192...206.5		97480...245		94063...287		90899...333		
	105183...171.7		101127...207.1		97420...246		94009...288		90848...333		
6	105113...172.3		101063...207.8		97361...247		93954...289		90798...334		24
7	105042...172.8		100998...208.4		97302...247		93899...289		90747...335		23
	104971...173.4		100934...209.0		97243...248		93845...290		90696...336		
	104901...174.0		100870...209.6		97184...249		93790...291		90646...337		
8	104830...174.5		100806...210.3		97126...249		93736...292		90595...337		22
9	104760...175.1		100742...210.9		97067...250		93682...292		90545...338		21
	104690...175.7		100678...211.5		97008...251		93628...293		90494...339		
	104620...176.2		100614...212.1		96950...251		93573...294		90444...340		
10	104550...176.8		100550...212.8		96891...252		93519...295		90394...341		20
11	104480...177.4		100487...213.4		96833...253		93465...295		90344...341		19
	104411...178.0		100423...214.0		96774...253		93411...296		90293...342		
	104341...178.5		100360...214.6		96716...254		93358...297		90243...343		
12	104272...179.1		100296...215.3		96658...255		93304...298		90193...344		18
13	104202...179.7		100233...215.9		96600...255		93250...298		90143...345		17
	104133...180.3		100170...216.5		96542...256		93196...299		90093...345		
	104064...180.8		100107...217.2		96484...257		93143...300		90044...346		
14	103995...181.4		100044...217.8		96426...257		93089...301		89994...347		16
15	103926...182.0		99981...218.4		96368...258		93036...301		89944...348		15
	103857...182.6		99918...219.1		96310...259		92982...302		89894...349		
	103788...183.2		99856...219.7		96253...260		92929...303		89845...349		
16	103720...183.7		99793...220.3		96195...260		92876...304		89795...350		14
17	103651...184.3		99731...221.0		96138...261		92823...304		89746...351		13
	103583...184.9		99668...221.6		96080...262		92769...305		89696...352		
	103515...185.5		99606...222.3		96023...262		92716...306		89647...353		
18	103447...186.1		99544...222.9		95966...263		92663...307		89597...353		12
19	103379...186.7		99481...223.5		95909...264		92610...307		89548...354		11
	103311...187.2		99420...224.2		95851...264		92558...308		89499...355		
	103243...187.8		99357...224.8		95795...265		92505...309		89450...356		
20	103175...188.4		99296...225.5		95737...266		92452...310		89401...357		10
21	103107...189.0		99234...226.1		95681...267		92399...310		89352...357		9
	103040...189.6		99172...226.8		95624...267		92347...311		89303...358		
	102973...190.2		99110...227.4		95567...268		92294...312		89254...359		
22	102905...190.8		99049...228.1		95510...269		92242...313		89205...360		8
23	102838...191.4		98988...228.7		95454...269		92189...313		89156...361		7
	102771...192.0		98926...229.4		95397...270		92137...314		89107...362		
	102704...192.6		98865...230.0		95341...271		92085...315		89059...362		
24	102637...193.2		98804...230.7		95285...271		92032...316		89010...363		6
25	102570...193.8		98743...231.3		95228...272		91980...316		88961...364		5
	102504...194.4		98682...232.0		95172...273		91928...317		88913...365		
	102437...195.0		98621...232.6		95116...274		91876...318		88864...366		
26	102371...195.6		98560...233.3		95060...274		91824...319		88816...366		4
27	102304...196.2		98499...233.9		95004...275		91772...319		88767...367		3
	102238...196.8		98439...234.6		94948...276		91720...320		88719...368		
	102172...197.4		98378...235.3		94892...276		91668...321		88671...369		
28	102106...198.0		98318...235.9		94836...277		91617...322		88623...370		2
29	102040...198.6		98257...236.6		94781...278		91565...323		88574...371		1
	101974...199.2		98197...237.2		94725...279		91514...323		88526...371		
	101908...199.8		98137...237.9		94670...279		91462...324		88478...372		
30	101843...200.4		98076...238.6		94614...280		91411...325		88430...373		0
	A	B	A	B	A	B	A	B	A	B	
	174°30'		174°00'		173°30'		173°00'		172°30'		

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	7°30'		8°00'		8°30'		9°00'		9°30'		
	A	B	A	B	A	B	A	B	A	B	
0	88430.....373		85644.....425		83030.....480		80567.....538		78239.....600		30
1	88382.....374		85599.....426		82987.....481		80527.....539		78201.....601		29
	88334.....375		85555.....426		82945.....482		80487.....540		78164.....602		
	88286.....376		85510.....427		82903.....482		80447.....541		78126.....603		
2	88239.....376		85465.....428		82861.....483		80407.....542		78088.....604		28
3	88191.....377		85420.....429		82819.....484		80368.....543		78051.....605		27
	88143.....378		85376.....430		82777.....485		80328.....544		78013.....606		
	88096.....379		85331.....431		82735.....486		80288.....545		77976.....607		
4	88048.....380		85286.....432		82693.....487		80249.....546		77938.....608		26
5	88001.....381		85242.....433		82651.....488		80209.....547		77901.....609		25
	87953.....381		85197.....434		82609.....489		80170.....548		77863.....610		
	87906.....382		85153.....434		82567.....490		80130.....549		77826.....611		
6	87858.....383		85108.....435		82526.....491		80091.....550		77788.....612		24
7	87811.....384		85064.....436		82484.....492		80051.....551		77751.....614		23
	87764.....385		85020.....437		82442.....493		80012.....552		77714.....615		
	87716.....386		84976.....438		82400.....494		79973.....553		77677.....616		
8	87669.....387		84931.....439		82359.....495		79933.....554		77639.....617		22
9	87622.....387		84887.....440		82317.....496		79894.....555		77602.....618		21
	87575.....388		84843.....441		82276.....497		79855.....556		77565.....619		
	87528.....389		84799.....442		82234.....498		79816.....557		77528.....620		
10	87481.....390		84755.....443		82193.....499		79777.....558		77491.....621		20
11	87434.....391		84711.....444		82151.....500		79737.....559		77454.....622		19
	87387.....392		84667.....444		82110.....501		79698.....560		77417.....623		
	87341.....392		84623.....445		82069.....502		79659.....561		77380.....624		
12	87294.....393		84579.....446		82027.....503		79620.....562		77343.....625		18
13	87247.....394		84535.....447		81986.....504		79581.....563		77306.....626		17
	87201.....395		84492.....448		81945.....504		79542.....564		77269.....627		
	87154.....396		84448.....449		81904.....505		79503.....565		77232.....629		
14	87107.....397		84404.....450		81863.....506		79465.....566		77195.....630		16
15	87061.....398		84361.....451		81821.....507		79426.....567		77158.....631		15
	87015.....399		84317.....452		81780.....508		79387.....568		77122.....632		
	86968.....399		84273.....453		81739.....509		79348.....569		77085.....633		
16	86922.....400		84230.....454		81698.....510		79309.....570		77048.....634		14
17	86876.....401		84186.....454		81657.....511		79271.....571		77011.....635		13
	86829.....402		84143.....455		81617.....512		79232.....573		76975.....636		
	86783.....403		84100.....456		81578.....513		79193.....574		76938.....637		
18	86737.....404		84056.....457		81535.....514		79155.....575		76902.....638		12
19	86691.....405		84013.....458		81494.....515		79116.....576		76865.....639		11
	86645.....405		83970.....459		81453.....516		79078.....577		76828.....641		
	86599.....406		83927.....460		81413.....517		79039.....578		76792.....642		
20	86553.....407		83884.....461		81372.....518		79001.....579		76756.....643		10
21	86507.....408		83840.....462		81331.....519		78962.....580		76719.....644		9
	86461.....409		83797.....463		81291.....520		78924.....581		76683.....645		
	86415.....410		83754.....464		81250.....521		78886.....582		76646.....646		
22	86370.....411		83711.....465		81210.....522		78847.....583		76610.....647		8
23	86324.....411		83668.....466		81169.....523		78809.....584		76574.....648		7
	86278.....412		83626.....467		81129.....524		78771.....585		76537.....649		
	86233.....413		83583.....467		81088.....525		78733.....586		76501.....650		
24	86187.....414		83540.....468		81048.....526		78694.....587		76465.....652		6
25	86142.....415		83497.....469		81008.....527		78656.....588		76429.....653		5
	86096.....416		83455.....470		80967.....528		78618.....589		76393.....654		
	86051.....417		83412.....471		80927.....529		78580.....590		76357.....655		
26	86006.....418		83369.....472		80887.....530		78542.....591		76320.....656		4
27	85960.....418		83327.....473		80847.....531		78504.....592		76284.....657		3
	85915.....419		83284.....474		80807.....532		78466.....593		76248.....658		
	85870.....420		83242.....475		80767.....533		78428.....594		76212.....659		
28	85825.....421		83199.....476		80727.....534		78390.....595		76176.....660		2
29	85779.....422		83157.....477		80687.....535		78352.....597		76141.....661		1
	85734.....423		83114.....478		80647.....536		78315.....598		76105.....663		
	85689.....424		83072.....479		80607.....537		78277.....599		76069.....664		
30	85644.....425		83030.....480		80567.....538		78239.....600		76033.....665		0
	A	B	A	B	A	B	A	B	A	B	
	172°00'		171°30'		171°00'		170°30'		170°00'		

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

	10°00'		10°30'		11°00'		11°30'		12°00'		
	A	B	A	B	A	B	A	B	A	B	
0	76033.....665		73937.....733		71940.....805		70034.....881		68212.....960		30
1	75997.....666		73903.....735		71908.....807		70003.....882		68182.....961		29
	75961.....667		73869.....736		71875.....808		69972.....883		68153.....962		
	75926.....668		73835.....737		71843.....809		69941.....885		68123.....964		
2	75890.....669		73801.....738		71810.....810		69910.....886		68093.....965		28
3	75854.....670		73767.....739		71778.....811		69879.....887		68064.....966		27
	75819.....672		73733.....740		71746.....813		69849.....888		68034.....968		
	75783.....673		73699.....742		71713.....814		69818.....890		68005.....969		
4	75747.....674		73665.....743		71681.....815		69787.....891		67975.....970		26
5	75712.....675		73631.....744		71649.....816		69756.....892		67945.....972		25
	75676.....676		73597.....745		71616.....818		69725.....894		67916.....973		
	75641.....677		73563.....746		71584.....819		69694.....895		67886.....974		
6	75605.....678		73530.....747		71552.....820		69664.....896		67857.....976		24
7	75570.....679		73496.....749		71520.....821		69633.....897		67828.....977		23
	75534.....680		73462.....750		71488.....823		69602.....899		67796.....978		
	75499.....682		73429.....751		71455.....824		69571.....900		67769.....980		
8	75464.....683		73395.....752		71423.....825		69541.....901		67739.....981		22
9	75428.....684		73361.....753		71391.....826		69510.....903		67710.....982		21
	75393.....685		73328.....755		71359.....828		69479.....904		67681.....984		
	75358.....686		73294.....756		71327.....829		69449.....905		67651.....985		
10	75322.....687		73260.....757		71295.....830		69418.....907		67622.....987		20
11	75287.....688		73227.....758		71263.....831		69387.....908		67593.....988		19
	75252.....690		73193.....759		71231.....833		69357.....909		67563.....989		
	75217.....691		73160.....761		71199.....834		69326.....910		67534.....991		
12	75182.....692		73127.....762		71167.....835		69296.....912		67505.....992		18
13	75147.....693		73093.....763		71135.....836		69265.....913		67476.....993		17
	75112.....694		73060.....764		71104.....838		69235.....914		67447.....995		
	75077.....695		73026.....765		71072.....839		69204.....916		67417.....996		
14	75042.....696		72993.....766		71040.....840		69174.....917		67388.....997		16
15	75007.....698		72960.....768		71008.....841		69144.....918		67359.....999		15
	74972.....699		72926.....769		70976.....843		69113.....920		67330.....1000		
	74937.....700		72893.....770		70945.....844		69083.....921		67301.....1002		
16	74902.....701		72860.....771		70913.....845		69053.....922		67272.....1003		14
17	74867.....702		72827.....772		70881.....846		69022.....924		67243.....1004		13
	74832.....703		72794.....774		70850.....848		68992.....925		67214.....1006		
	74797.....704		72760.....775		70818.....849		68962.....926		67185.....1007		
18	74763.....706		72727.....776		70786.....850		68931.....928		67156.....1008		12
19	74728.....707		72694.....777		70755.....851		68901.....929		67127.....1010		11
	74693.....708		72661.....779		70723.....853		68871.....930		67098.....1011		
	74659.....709		72628.....780		70692.....854		68841.....932		67069.....1013		
20	74624.....710		72595.....781		70660.....855		68811.....933		67040.....1014		10
21	74589.....711		72562.....782		70629.....856		68781.....934		67011.....1015		9
	74555.....712		72529.....783		70597.....858		68750.....935		66982.....1017		
	74520.....714		72496.....785		70566.....859		68720.....937		66953.....1018		
22	74486.....715		72463.....786		70534.....860		68690.....938		66925.....1020		8
23	74451.....716		72430.....787		70503.....862		68660.....939		66896.....1021		7
	74417.....717		72397.....788		70471.....863		68630.....941		66867.....1022		
	74382.....718		72365.....790		70440.....864		68600.....942		66838.....1024		
24	74348.....719		72332.....791		70409.....865		68570.....943		66810.....1025		6
25	74313.....721		72299.....792		70377.....867		68540.....945		66781.....1026		5
	74279.....722		72266.....793		70346.....868		68510.....946		66752.....1028		
	74245.....723		72234.....794		70315.....869		68480.....947		66724.....1029		
26	74210.....724		72201.....796		70284.....870		68450.....949		66695.....1031		4
27	74176.....725		72168.....797		70252.....872		68421.....950		66666.....1032		3
	74142.....726		72135.....798		70221.....873		68391.....951		66638.....1033		
	74107.....728		72103.....799		70190.....874		68361.....953		66609.....1035		
28	74073.....729		72070.....800		70159.....876		68331.....954		66580.....1036		2
29	74039.....730		72038.....802		70128.....877		68301.....955		66552.....1038		1
	74005.....731		72005.....803		70097.....878		68272.....957		66523.....1039		
	73971.....732		71973.....804		70065.....879		68242.....958		66495.....1040		
30	73937.....733		71940.....805		70034.....881		68212.....960		66466.....1042		0
	A	B	A	B	A	B	A	B	A	B	
	169°30'		169°00'		168°30'		168°00'		167°30'		

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	12°30'		13°00'		13°30'		14°00'		14°30'		
	A	B	A	B	A	B	A	B	A	B	
0	66466.....1042		64791.....1128		63181.....1217		61632.....1310		60140.....1406		30
1	66438.....1043		64764.....1129		63155.....1218		61607.....1311		60116.....1407		29
	66409.....1045		64736.....1130		63129.....1220		61582.....1313		60091.....1409		
	66381.....1046		64709.....1132		63103.....1221		61556.....1314		60067.....1411		
2	66352.....1047		64682.....1133		63076.....1223		61531.....1316		60042.....1412		28
3	66324.....1049		64655.....1135		63050.....1224		61506.....1317		60018.....1414		27
	66296.....1050		64627.....1136		63024.....1226		61481.....1319		59994.....1416		
	66267.....1052		64600.....1138		62998.....1227		61455.....1321		59969.....1417		
4	66239.....1053		64573.....1139		62971.....1229		61430.....1322		59945.....1419		26
5	66211.....1054		64546.....1141		62945.....1230		61405.....1324		59921.....1421		25
	66182.....1056		64518.....1142		62919.....1232		61380.....1325		59896.....1422		
	66154.....1057		64491.....1144		62893.....1234		61355.....1327		59872.....1424		
6	66126.....1059		64464.....1145		62867.....1235		61330.....1329		59848.....1425		24
7	66098.....1060		64437.....1147		62841.....1237		61304.....1330		59824.....1427		23
	66069.....1061		64410.....1148		62815.....1238		61279.....1332		59800.....1429		
	66041.....1063		64383.....1150		62789.....1240		61254.....1333		59775.....1430		
8	66013.....1064		64356.....1151		62763.....1241		61229.....1335		59751.....1432		22
9	65985.....1066		64329.....1152		62737.....1243		61204.....1336		59727.....1434		21
	65957.....1067		64302.....1154		62711.....1244		61179.....1338		59703.....1435		
	65928.....1069		64275.....1155		62685.....1246		61154.....1340		59679.....1437		
10	65900.....1070		64248.....1157		62659.....1247		61129.....1341		59654.....1439		20
11	65872.....1071		64221.....1158		62633.....1249		61104.....1343		59630.....1440		19
	65844.....1073		64194.....1160		62607.....1250		61079.....1344		59606.....1442		
	65816.....1074		64167.....1161		62581.....1252		61054.....1346		59582.....1444		
12	65788.....1076		64140.....1163		62555.....1253		61029.....1348		59558.....1445		18
13	65760.....1077		64113.....1164		62529.....1255		61004.....1349		59534.....1447		17
	65732.....1079		64086.....1166		62503.....1257		60979.....1351		59510.....1449		
	65704.....1080		64059.....1167		62477.....1258		60954.....1352		59486.....1450		
14	65676.....1081		64032.....1169		62451.....1260		60929.....1354		59462.....1452		16
15	65648.....1083		64005.....1170		62425.....1261		60904.....1356		59438.....1454		15
	65620.....1084		63978.....1172		62400.....1263		60879.....1357		59414.....1455		
	65592.....1086		63952.....1173		62374.....1264		60855.....1359		59390.....1457		
16	65564.....1087		63925.....1175		62348.....1266		60830.....1360		59366.....1459		14
17	65537.....1089		63898.....1176		62322.....1267		60805.....1362		59342.....1460		13
	65509.....1090		63871.....1178		62296.....1269		60780.....1364		59318.....1462		
	65481.....1091		63845.....1179		62271.....1270		60755.....1365		59294.....1464		
18	65453.....1093		63818.....1181		62245.....1272		60730.....1367		59270.....1465		12
19	65425.....1094		63791.....1182		62219.....1274		60706.....1368		59246.....1467		11
	65398.....1096		63764.....1184		62194.....1275		60681.....1370		59222.....1469		
	65370.....1097		63738.....1185		62168.....1277		60656.....1372		59198.....1470		
20	65342.....1099		63711.....1187		62142.....1278		60631.....1373		59175.....1472		10
21	65314.....1100		63684.....1188		62117.....1280		60607.....1375		59151.....1474		9
	65287.....1101		63658.....1190		62091.....1281		60582.....1377		59127.....1475		
	65259.....1103		63631.....1191		62065.....1283		60557.....1378		59103.....1477		
22	65231.....1104		63605.....1193		62040.....1284		60533.....1380		59079.....1479		8
23	65204.....1106		63578.....1194		62014.....1286		60508.....1381		59055.....1480		7
	65176.....1107		63551.....1196		61989.....1288		60483.....1383		59032.....1482		
	65148.....1109		63525.....1197		61963.....1289		60459.....1385		59008.....1484		
24	65121.....1110		63498.....1199		61938.....1291		60434.....1386		58984.....1485		6
25	65093.....1112		63472.....1200		61912.....1292		60410.....1388		58960.....1487		5
	65066.....1113		63445.....1202		61887.....1294		60385.....1390		58937.....1489		
	65038.....1114		63419.....1203		61861.....1295		60360.....1391		58913.....1490		
26	65011.....1116		63392.....1205		61836.....1297		60336.....1393		58889.....1492		4
27	64983.....1117		63366.....1206		61810.....1299		60311.....1394		58866.....1494		3
	64956.....1119		63340.....1208		61785.....1300		60287.....1396		58842.....1495		
	64928.....1120		63313.....1209		61759.....1301		60262.....1398		58818.....1497		
28	64901.....1122		63287.....1211		61734.....1303		60238.....1399		58795.....1499		2
29	64873.....1123		63260.....1212		61709.....1305		60213.....1401		58771.....1500		1
	64846.....1125		63234.....1214		61683.....1306		60189.....1403		58748.....1502		
	64819.....1126		63208.....1215		61658.....1308		60164.....1404		58724.....1504		
30	64791.....1128		63181.....1217		61632.....1310		60140.....1406		58700.....1506		0
	A	B	A	B	A	B	A	B	A	B	
	167°00'		166°30'		166°00'		165°30'		165°00'		

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

	15°00'		15°30'		16°00'		16°30'		17°00'		
	A	B	A	B	A	B	A	B	A	B	
0	58700.....1506		57310.....1609		55966.....1716		54666.....1826		53406.....1940		30
1	58677.....1507		57287.....1611		55944.....1718		54644.....1828		53386.....1942		29
	58653.....1509		57265.....1612		55922.....1719		54623.....1830		53365.....1944		
	58630.....1511		57242.....1614		55900.....1721		54602.....1832		53344.....1946'		
2	58606.....1512		57219.....1616		55878.....1723		54581.....1834		53324.....1948		28
3	58583.....1514		57196.....1618		55856.....1725		54559.....1836		53303.....1950		27
	58559.....1516		57174.....1619		55834.....1727		54538.....1837		53283.....1952		
	58536.....1517		57151.....1621		55812.....1728		54517.....1839		53262.....1954		
4	58512.....1519		57128.....1623		55790.....1730		54496.....1841		53241.....1956		26
5	58489.....1521		57106.....1625		55768.....1732		54474.....1843		53221.....1958		25
	58465.....1523		57083.....1627		55746.....1734		54453.....1845		53200.....1960		
	58442.....1524		57060.....1628		55725.....1736		54432.....1847		53180.....1962		
6	58418.....1526		57038.....1630		55703.....1738		54411.....1849		53159.....1964		24
7	58395.....1528		57015.....1632		55681.....1739		54390.....1851		53139.....1966		23
	58372.....1529		56992.....1634		55659.....1741		54368.....1853		53118.....1967		
	58348.....1531		56970.....1935		55637.....1743		54347.....1854		53098.....1969		
8	58325.....1533		56947.....1637		55615.....1745		54326.....1856		53077.....1971		22
9	58302.....1534		56925.....1639		55593.....1747		54305.....1858		53057.....1973		21
	58278.....1536		56902.....1641		55572.....1749		54284.....1860		53036.....1975		
	58255.....1538		56880.....1642		55550.....1750		54263.....1862		53016.....1977		
10	58232.....1540		56857.....1644		55528.....1752		54242.....1864		52995.....1979		20
11	58208.....1541		56835.....1646		55506.....1754		54220.....1866		52975.....1981		19
	58185.....1543		56812.....1648		55484.....1756		54199.....1868		52954.....1983		
	58162.....1545		56790.....1649		55463.....1758		54178.....1870		52934.....1985		
12	58138.....1546		56767.....1651		55441.....1760		54157.....1871		52914.....1987		18
13	58115.....1548		56745.....1653		55419.....1761		54136.....1873		52893.....1989		17
	58092.....1550		56722.....1655		55397.....1763		54115.....1875		52873.....1991		
	58069.....1552		56700.....1657		55376.....1765		54094.....1877		52852.....1993		
14	58046.....1553		56677.....1658		55354.....1767		54073.....1879		52832.....1995		16
15	58022.....1555		56655.....1660		55332.....1769		54052.....1881		52812.....1997		15
	57999.....1557		56632.....1662		55311.....1771		54031.....1883		52791.....1999		
	57976.....1559		56610.....1664		55289.....1772		54010.....1885		52771.....2001		
16	57953.....1560		56588.....1665		55267.....1774		53989.....1887		52751.....2003		14
17	57930.....1562		56565.....1667		55246.....1776		53968.....1889		52730.....2005		13
	57907.....1564		56543.....1669		55224.....1778		53947.....1890		52710.....2007		
	57884.....1565		56521.....1671		55202.....1780		53926.....1892		52690.....2009		
18	57860.....1567		56498.....1673		55181.....1782		53905.....1894		52670.....2010		12
19	57837.....1569		56476.....1674		55159.....1783		53884.....1896		52649.....2012		11
	57814.....1571		56454.....1676		55138.....1785		53864.....1898		52629.....2014		
	57791.....1572		56431.....1678		55116.....1787		53843.....1900		52609.....2016		
20	57768.....1574		56409.....1680		55095.....1789		53822.....1902		52588.....2018		10
21	57745.....1576		56387.....1682		55073.....1791		53801.....1904		52568.....2020		9
	57722.....1578		56365.....1683		55051.....1793		53780.....1906		52548.....2022		
	57699.....1579		56342.....1685		55030.....1795		53759.....1908		52528.....2024		
22	57676.....1581		56320.....1687		55008.....1796		53738.....1910		52508.....2026		8
23	57653.....1583		56298.....1689		54987.....1798		53718.....1911		52487.....2028		7
	57630.....1584		56276.....1691		54965.....1800		53697.....1913		52467.....2030		
	57607.....1586		56254.....1692		54944.....1802		53676.....1915		52447.....2032		
24	57584.....1588		56231.....1694		54922.....1804		53655.....1917		52427.....2034		6
25	57561.....1590		56209.....1696		54901.....1806		53634.....1919		52407.....2036		5
	57538.....1591		56187.....1698		54880.....1808		53614.....1921		52387.....2038		
	57516.....1593		56165.....1700		54858.....1809		53593.....1923		52366.....2040		
26	57493.....1595		56143.....1701		54837.....1811		53572.....1925		52346.....2042		4
27	57470.....1597		56121.....1703		54815.....1813		53551.....1927		52326.....2044		3
	57447.....1598		56099.....1705		54794.....1815		53531.....1929		52306.....2046		
	57424.....1600		56076.....1707		54773.....1817		53510.....1931		52286.....2048		
28	57401.....1602		56054.....1709		54751.....1819		53489.....1933		52266.....2050		2
29	57378.....1604		56032.....1710		54730.....1821		53468.....1935		52246.....2052		1
	57356.....1605		56010.....1712		54708.....1823		53448.....1936		52226.....2054		
	57333.....1607		55988.....1714		54687.....1824		53427.....1938		52206.....2056		
30	57310.....1609		55966.....1716		54666.....1826		53406.....1940		52186.....2058		0
	A	B	A	B	A	B	A	B	A	B	
	164°30'		164°00'		163°30'		163°00'		162°30'		

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	17°30'		18°00'		18°30'		19°00'		19°30'		
	A	B	A	B	A	B	A	B	A	B	
0	52186.....2058		51002.....2179		49852.....2304		48736.....2433		47650.....2565		30
1	52166.....2060		50982.....2181		49833.....2306		48717.....2435		47633.....2568		29
	52146.....2062		50963.....2183		49815.....2309		48699.....2437		47615.....2570		
	52126.....2064		50943.....2185		49796.....2311		48681.....2439		47597.....2572		
2	52106.....2066		50924.....2188		49777.....2313		48662.....2442		47579.....2574		28
3	52086.....2068		50905.....2190		49758.....2315		48644.....2444		47561.....2576		27
	52066.....2070		50885.....2192		49739.....2317		48626.....2446		47544.....2579		
	52046.....2072		50866.....2194		49720.....2319		48608.....2448		47526.....2581		
4	52026.....2074		50846.....2196		49702.....2321		48589.....2450		47508.....2583		26
5	52006.....2076		50827.....2198		49683.....2323		48571.....2453		47490.....2585		25
	51986.....2078		50808.....2200		49664.....2325		48553.....2456		47472.....2588		
	51966.....2080		50786.....2202		49645.....2328		48534.....2457		47455.....2590		
6	51946.....2082		50769.....2204		49626.....2330		48516.....2459		47437.....2592		24
7	51926.....2084		50750.....2206		49608.....2332		48498.....2461		47419.....2594		23
	51906.....2086		50730.....2208		49589.....2334		48480.....2463		47402.....2597		
	51886.....2088		50711.....2210		49570.....2336		48462.....2466		47384.....2599		
8	51867.....2090		50692.....2212		49551.....2338		48443.....2468		47366.....2601		22
9	51847.....2092		50673.....2214		49533.....2340		48425.....2470		47348.....2603		21
	51827.....2094		50653.....2216		49514.....2343		48407.....2472		47331.....2606		
	51807.....2096		50634.....2218		49495.....2345		48389.....2474		47313.....2608		
10	51787.....2098		50615.....2221		49477.....2347		48371.....2477		47295.....2610		20
11	51767.....2100		50596.....2223		49458.....2349		48352.....2479		47278.....2613		19
	51747.....2102		50576.....2225		49439.....2351		48334.....2481		47260.....2615		
	51728.....2104		50557.....2227		49421.....2353		48316.....2483		47242.....2617		
12	51708.....2106		50538.....2229		49402.....2355		48298.....2485		47225.....2619		18
13	51688.....2108		50519.....2231		49383.....2357		48280.....2488		47207.....2622		17
	51668.....2110		50499.....2233		49365.....2360		48262.....2490		47189.....2624		
	51649.....2112		50480.....2235		49346.....2362		48244.....2492		47172.....2626		
14	51629.....2114		50461.....2237		49327.....2364		48225.....2494		47154.....2628		16
15	51609.....2116		50442.....2239		49309.....2366		48207.....2496		47137.....2631		15
	51589.....2118		50423.....2241		49290.....2368		48189.....2499		47119.....2633		
	51570.....2120		50404.....2243		49271.....2370		48171.....2501		47101.....2635		
16	51550.....2122		50385.....2246		49253.....2372		48153.....2503		47084.....2637		14
17	51530.....2124		50365.....2248		49234.....2375		48135.....2505		47066.....2640		13
	51510.....2126		50346.....2250		49216.....2377		48117.....2507		47049.....2642		
	51491.....2128		50327.....2252		49197.....2379		48099.....2510		47031.....2644		
18	51471.....2130		50308.....2254		49179.....2381		48081.....2512		47014.....2646		12
19	51451.....2132		50289.....2256		49160.....2383		48063.....2514		46996.....2649		11
	51432.....2134		50270.....2258		49141.....2385		48045.....2516		46978.....2651		
	51412.....2136		50251.....2260		49123.....2387		48027.....2519		46961.....2653		
20	51392.....2138		50232.....2262		49104.....2390		48009.....2521		46943.....2656		10
21	51373.....2141		50213.....2264		49086.....2392		47991.....2523		46926.....2658		9
	51353.....2143		50194.....2266		49067.....2394		47973.....2525		46908.....2660		
	51334.....2145		50175.....2269		49049.....2396		47955.....2527		46891.....2662		
22	51314.....2147		50156.....2271		49030.....2398		47937.....2530		46873.....2665		8
23	51294.....2149		50137.....2273		49012.....2400		47919.....2532		46856.....2667		7
	51275.....2151		50117.....2275		48993.....2403		47901.....2534		46839.....2669		
	51255.....2153		50098.....2277		48975.....2405		47883.....2536		46821.....2672		
24	51236.....2155		50080.....2279		48957.....2407		47865.....2539		46804.....2674		6
25	51216.....2157		50061.....2281		48938.....2409		47847.....2541		46786.....2676		5
	51197.....2159		50042.....2283		48920.....2411		47829.....2543		46769.....2678		
	51177.....2161		50023.....2285		48901.....2413		47811.....2545		46751.....2681		
26	51158.....2163		50004.....2287		48883.....2416		47793.....2547		46734.....2683		4
27	51138.....2165		49985.....2290		48864.....2418		47775.....2550		46716.....2685		3
	51119.....2167		49966.....2292		48846.....2420		47758.....2552		46699.....2688		
	51099.....2169		49947.....2294		48828.....2422		47740.....2554		46682.....2690		
28	51080.....2171		49928.....2296		48809.....2424		47722.....2556		46664.....2692		2
29	51060.....2173		49909.....2298		48791.....2426		47704.....2559		46647.....2694		1
	51041.....2175		49890.....2300		48772.....2429		47686.....2561		46630.....2697		
	51021.....2177		49871.....2302		48754.....2431		47668.....2563		46612.....2699		
30	51002.....2179		49852.....2304		48736.....2433		47650.....2565		46595.....2701		0
	A	B	A	B	A	B	A	B	A	B	
	162°00'		161°30'		161°00'		160°30'		160°00'		

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

	20°00'		20°30'		21°00'		21°30'		22°00'		
	A	B	A	B	A	B	A	B	A	B	
0	46595.....2701		45567.....2841		44567.....2985		43592.....3132		42642.....3283		30
1	46577.....2704		45551.....2844		44551.....2988		43576.....3135		42627.....3286		29
	46560.....2706		45534.....2846		44534.....2990		43560.....3137		42611.....3288		
	46543.....2708		45517.....2848		44518.....2992		43544.....3140		42596.....3291		
2	46525.....2711		45500.....2851		44501.....2994		43528.....3142		42580.....3294		28
3	46508.....2713		45483.....2853		44485.....2997		43512.....3145		42564.....3296		27
	46491.....2715		45466.....2855		44468.....2999		43496.....3147		42549.....3299		
	46473.....2717		45449.....2858		44452.....3002		43480.....3150		42533.....3301		
4	46456.....2720		45433.....2860		44436.....3004		43464.....3152		42518.....3304		26
5	46439.....2722		45416.....2862		44419.....3007		43448.....3155		42502.....3306		25
	46422.....2724		45399.....2865		44403.....3009		43432.....3157		42486.....3309		
	46404.....2727		45382.....2867		44386.....3012		43416.....3160		42471.....3312		
6	46387.....2729		45365.....2870		44370.....3014		43400.....3162		42455.....3314		24
7	46370.....2731		45348.....2872		44354.....3016		43385.....3165		42449.....3317		23
	46353.....2734		45332.....2874		44337.....3019		43369.....3167		42434.....3319		
	46335.....2736		45315.....2877		44321.....3021		43353.....3170		42409.....3322		
8	46318.....2738		45298.....2879		44305.....3024		43337.....3172		42393.....3324		22
9	46301.....2741		45281.....2881		44288.....3026		43321.....3175		42378.....3327		21
	46284.....2743		45265.....2884		44272.....3029		43305.....3177		42362.....3329		
	46266.....2745		45248.....2886		44256.....3031		43289.....3180		42347.....3332		
10	46249.....2748		45231.....2889		44239.....3033		43273.....3182		42331.....3335		20
11	46232.....2750		45214.....2891		44223.....3036		43257.....3185		42316.....3337		19
	46215.....2752		45198.....2893		44207.....3038		43241.....3187		42300.....3340		
	46198.....2755		45181.....2896		44190.....3041		43225.....3190		42285.....3342		
12	46181.....2757		45164.....2898		44174.....3043		43210.....3192		42269.....3345		18
13	46163.....2759		45147.....2901		44158.....3046		43194.....3195		42254.....3347		17
	46146.....2761		45131.....2903		44142.....3048		43178.....3197		42238.....3350		
	46129.....2764		45114.....2905		44125.....3051		43162.....3200		42223.....3353		
14	46112.....2766		45097.....2908		44109.....3053		43146.....3202		42207.....3355		16
15	46095.....2768		45081.....2910		44093.....3056		43130.....3205		42192.....3358		15
	46078.....2771		45064.....2913		44077.....3058		43114.....3207		42176.....3360		
	46061.....2773		45047.....2915		44060.....3060		43099.....3210		42161.....3363		
16	46043.....2775		45031.....2917		44044.....3063		43083.....3212		42145.....3366		14
17	46026.....2778		45014.....2920		44028.....3065		43067.....3215		42130.....3368		13
	46009.....2780		44997.....2922		44012.....3068		43051.....3217		42115.....3371		
	45992.....2782		44981.....2924		43995.....3070		43035.....3220		42099.....3373		
18	45975.....2785		44964.....2927		43979.....3073		43020.....3222		42084.....3376		12
19	45958.....2787		44947.....2929		43963.....3075		43004.....3225		42068.....3379		11
	45941.....2789		44931.....2932		43947.....3078		42988.....3227		42053.....3381		
	45924.....2792		44914.....2934		43931.....3080		42972.....3230		42038.....3384		
20	45907.....2794		44898.....2936		43914.....3083		42956.....3233		42022.....3386		10
21	45890.....2797		44881.....2939		43898.....3085		42941.....3235		42007.....3389		9
	45873.....2799		44864.....2941		43882.....3088		42925.....3238		41991.....3391		
	45856.....2801		44848.....2944		43866.....3090		42909.....3240		41976.....3394		
22	45839.....2804		44831.....2946		43850.....3092		42893.....3243		41961.....3387		8
23	45822.....2806		44815.....2949		43834.....3095		42878.....3245		41945.....3399		7
	45805.....2808		44798.....2951		43818.....3097		42862.....3248		41930.....3402		
	45788.....2811		44782.....2953		43801.....3100		42846.....3250		41915.....3404		
24	45771.....2813		44765.....2956		43785.....3102		42830.....3253		41899.....3407		6
25	45754.....2815		44748.....2958		43769.....3105		42815.....3255		41884.....3410		5
	45737.....2818		44732.....2961		43753.....3107		42799.....3258		41869.....3412		
	45720.....2820		44715.....2963		43737.....3110		42783.....3260		41853.....3415		
26	45703.....2822		44699.....2965		43721.....3112		42768.....3263		41838.....3418		4
27	45686.....2825		44682.....2968		43705.....3115		42752.....3266		41823.....3420		3
	45669.....2827		44666.....2970		43689.....3117		42736.....3268		41808.....3423		
	45652.....2829		44649.....2973		43673.....3120		42721.....3271		41792.....3425		
28	45635.....2832		44633.....2975		43657.....3122		42705.....3273		41777.....3428		2
29	45618.....2834		44616.....2978		43641.....3125		42689.....3276		41762.....3431		1
	45601.....2836		44600.....2980		43624.....3127		42674.....3278		41746.....3433		
	45584.....2839		44583.....2982		43608.....3130		43658.....3281		41731.....3436		
30	45567.....2841		44567.....2985		43592.....3132		42642.....3283		41716.....3438		0
	A	B	A	B	A	B	A	B	A	B	
	159°30'		159°00'		158°30'		158°00'		157°30'		

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	22°30'		23°00'		23°30'		24°00'		24°30'		
	A	B	A	B	A	B	A	B	A	B	
0	41716.....3438		40812.....3597		39930.....3760		39069.....3927		38227.....4098		30
1	41701.....3441		40797.....3600		39915.....3763		39054.....3930		38213.....4101		29
	41685.....3444		40782.....3603		39901.....3766		39040.....3932		38200.....4103		
	41670.....3446		40768.....3605		39886.....3768		39026.....3935		38186.....4106		
2	41655.....3449		40753.....3608		39872.....3771		39012.....3938		38172.....4109		28
3	41640.....3452		40738.....3611		39857.....3774		38998.....3941		38158.....4112		27
	41625.....3454		40723.....3613		39843.....3777		38984.....3944		38144.....4115		
	41609.....3457		40708.....3616		39828.....3779		38969.....3947		38130.....4118		
4	41594.....3459		40693.....3619		39814.....3782		38955.....3949		38117.....4121		26
5	41579.....3462		40678.....3622		39799.....3785		38941.....3952		38103.....4124		25
	41564.....3465		40664.....3624		39785.....3788		38927.....3955		38089.....4127		
	41549.....3467		40649.....3627		39771.....3790		38913.....3958		38075.....4129		
6	41533.....3470		40634.....3630		39756.....3793		38899.....3961		38061.....4132		24
7	41518.....3473		40619.....3632		39742.....3796		38885.....3964		38048.....4135		23
	41503.....3475		40604.....3635		39727.....3799		38871.....3966		38034.....4138		
	41488.....3478		40590.....3638		39713.....3801		38856.....3969		38020.....4141		
8	41473.....3480		40575.....3640		39698.....3804		38842.....3972		38006.....4144		22
9	41458.....3483		40560.....3643		39684.....3807		38828.....3975		37992.....4147		21
	41443.....3486		40545.....3646		39669.....3810		38814.....3978		37979.....4150		
	41427.....3488		40530.....3648		39655.....3813		38800.....3981		37965.....4153		
10	41412.....3491		40516.....3651		39641.....3815		38786.....3983		37951.....4155		20
11	41397.....3494		40501.....3654		39626.....3818		38772.....3986		37937.....4158		19
	41382.....3496		40486.....3657		39612.....3821		38758.....3989		37924.....4161		
	41367.....3499		40471.....3659		39597.....3824		38744.....3992		37910.....4164		
12	41352.....3502		40457.....3662		39583.....3826		38730.....3995		37896.....4167		18
13	41337.....3504		40442.....3665		39569.....3829		38716.....3998		37882.....4170		17
	41322.....3507		40427.....3667		39554.....3832		38702.....4000		37869.....4173		
	41307.....3509		40413.....3670		39540.....3835		38688.....4003		37855.....4176		
14	41291.....3512		40398.....3673		39525.....3838		38674.....4006		37841.....4179		16
15	41276.....3515		40383.....3676		39511.....3840		38660.....4009		37828.....4182		15
	41261.....3517		40368.....3678		39497.....3843		38645.....4012		37814.....4185		
	41246.....3520		40354.....3681		39482.....3846		38631.....4015		37800.....4187		
16	41231.....3523		40339.....3684		39468.....3849		38617.....4017		37786.....4190		14
17	41216.....3525		40324.....3686		39454.....3851		38603.....4020		37773.....4193		13
	41201.....3528		40310.....3689		39439.....3854		38589.....4023		37759.....4196		
	41186.....3531		40295.....3692		39425.....3857		38575.....4026		37745.....4199		
18	41171.....3533		40280.....3695		39411.....3860		38561.....4029		37732.....4202		12
19	41156.....3536		40266.....3697		39396.....3863		38547.....4032		37718.....4235		11
	41141.....3539		40251.....3700		39382.....3865		38533.....4035		37704.....4208		
	41126.....3541		40236.....3703		39368.....3868		38520.....4037		37691.....4211		
20	41111.....3544		40222.....3705		39353.....3871		38506.....4040		37677.....4214		10
21	41096.....3547		40207.....3708		39339.....3874		38492.....4043		37663.....4217		9
	41081.....3549		40192.....3711		39325.....3876		38478.....4046		37650.....4220		
	41066.....3552		40178.....3714		39311.....3879		38464.....4049		37636.....4222		
22	41051.....3555		40163.....3716		39296.....3882		38450.....4052		37623.....4225		8
23	41036.....3557		40149.....3719		39282.....3885		38436.....4055		37609.....4228		7
	41021.....3560		40134.....3722		39268.....3888		38422.....4057		37595.....4231		
	41006.....3563		40119.....3725		39254.....3890		38408.....4060		37582.....4234		
24	40991.....3565		40105.....3727		39239.....3893		38394.....4063		37568.....4237		6
25	40976.....3568		40090.....3730		39225.....3896		38380.....4066		37554.....4240		5
	40961.....3571		40076.....3733		39211.....3899		38366.....4069		37541.....4243		
	40946.....3573		40061.....3735		39197.....3902		38352.....4072		37527.....4246		
26	40931.....3576		40046.....3738		39182.....3904		38338.....4075		37514.....4249		4
27	40916.....3579		40032.....3741		39168.....3907		38324.....4078		37500.....4252		3
	40902.....3581		40017.....3744		39154.....3910		38311.....4080		37486.....4255		
	40887.....3584		40003.....3746		39140.....3913		38297.....4083		37473.....4258		
28	40872.....3587		39988.....3749		39125.....3916		38283.....4086		37459.....4261		2
29	40857.....3589		39974.....3752		39111.....3918		38269.....4089		37446.....4264		1
	40842.....3592		39959.....3755		39097.....3921		38255.....4092		37432.....4266		
	40827.....3595		39945.....3757		39083.....3924		38241.....4095		37419.....4269		
30	40812.....3597		39930.....3760		39069.....3927		38227.....4098		37405.....4272		0
	A	B	A	B	A	B	A	B	A	B	
	157°00'		156°30'		156°00'		155°30'		155°00'		

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

	25°00'		25°30'		26°00'		26°30'		27°00'		
	A	B	A	B	A	B	A	B	A	B	
0	37405.....4272		36602.....4451		35816.....4634		35047.....4821		34295.....5012		30
1	37392.....4275		36588.....4454		35803.....4637		35035.....4824		34283.....5015		29
	37378.....4278		36575.....4457		35790.....4640		35022.....4827		34270.....5018		
	37365.....4281		36562.....4460		35777.....4643		35009.....4830		34258.....5022		
2	37351.....4284		36549.....4463		35764.....4646		34997.....4833		34246.....5025		28
3	37337.....4287		36535.....4466		35751.....4649		34984.....4837		34233.....5028		27
	37324.....4290		36522.....4469		35738.....4651		34971.....4840		34221.....5031		
	37310.....4293		36509.....4472		35725.....4656		34959.....4843		34209.....5034		
4	37297.....4296		36496.....4475		35712.....4659		34946.....4846		34196.....5038		26
5	37283.....4299		36483.....4478		35699.....4662		34933.....4849		34184.....5041		25
	37270.....4302		36469.....4481		35686.....4665		34921.....4852		34172.....5044		
	37256.....4305		36456.....4484		35674.....4668		34908.....4856		34159.....5047		
6	37243.....4308		36443.....4487		35661.....4671		34896.....4859		34147.....5051		24
7	37229.....4311		36430.....4490		35648.....4674		34883.....4862		34134.....5054		23
	37216.....4314		36417.....4493		35635.....4677		34870.....4865		34122.....5057		
	37203.....4317		36403.....4496		35622.....4680		34858.....4868		34110.....5060		
8	37189.....4320		36390.....4499		35609.....4683		34845.....4871		34097.....5064		22
9	37176.....4323		36377.....4503		35596.....4686		34832.....4875		34085.....5067		21
	37162.....4326		36364.....4506		35583.....4690		34820.....4878		34073.....5070		
	37149.....4329		36351.....4509		35571.....4693		34807.....4881		34061.....5073		
10	37135.....4332		36338.....4512		35558.....4696		34795.....4884		34048.....5076		20
11	37122.....4334		36325.....4515		35545.....4699		34782.....4887		34036.....5080		19
	37108.....4337		36311.....4518		35532.....4702		34770.....4890		34024.....5083		
	37095.....4340		36298.....4521		35519.....4705		34757.....4894		34011.....5086		
12	37081.....4343		36285.....4524		35506.....4708		34744.....4897		33999.....5089		18
13	37068.....4346		36272.....4527		35493.....4711		34732.....4900		33987.....5093		17
	37055.....4349		36259.....4530		35481.....4714		34719.....4903		33974.....5096		
	37041.....4352		36246.....4533		35468.....4718		34707.....4906		33962.....5099		
14	37028.....4355		36233.....4536		35455.....4721		34694.....4910		33950.....5102		16
15	37014.....4358		36220.....4539		35442.....4724		34682.....4913		33938.....5106		15
	37001.....4361		36206.....4542		35429.....4727		34669.....4916		33925.....5109		
	36988.....4364		36193.....4545		35417.....4730		34657.....4919		33913.....5112		
16	36974.....4367		36180.....4548		35404.....4733		34644.....4922		33901.....5115		14
17	36961.....4370		36167.....4551		35391.....4736		34632.....4925		33889.....5119		13
	36948.....4373		36154.....4554		35378.....4739		34619.....4929		33876.....5122		
	36934.....4376		36141.....4557		35365.....4742		34607.....4932		33864.....5125		
18	36921.....4379		36128.....4560		35353.....4746		34594.....4935		33852.....5128		12
19	36907.....4382		36115.....4563		35340.....4749		34582.....4938		33840.....5132		11
	36894.....4385		36102.....4566		35327.....4752		34569.....4941		33827.....5135		
	36881.....4388		36089.....4569		35314.....4755		34557.....4945		33815.....5138		
20	36867.....4391		36076.....4573		35302.....4758		34544.....4948		33803.....5142		10
21	36854.....4394		36063.....4576		35289.....4761		34532.....4951		33791.....5145		9
	36841.....4397		36050.....4579		35276.....4764		34519.....4954		33779.....5148		
	36827.....4400		36037.....4582		35263.....4769		34507.....4957		33766.....5151		
22	36814.....4403		36024.....4585		35251.....4771		34494.....4961		33754.....5155		8
23	36801.....4406		36011.....4588		35238.....4774		34482.....4964		33742.....5158		7
	36787.....4409		35998.....4591		35225.....4777		34469.....4967		33730.....5161		
	36774.....4412		35985.....4594		35212.....4780		34457.....4970		33717.....5164		
24	36761.....4415		35972.....4597		35200.....4783		34445.....4973		33705.....5168		6
25	36747.....4418		35959.....4600		35187.....4786		34432.....4977		33693.....5171		5
	36734.....4421		35946.....4603		35174.....4789		34420.....4980		33681.....5174		
	36721.....4424		35933.....4606		35161.....4793		34407.....4983		33669.....5178		
26	36708.....4427		35920.....4609		35149.....4796		34395.....4986		33657.....5181		4
27	36694.....4430		35907.....4612		35136.....4799		34382.....4989		33644.....5184		3
	36681.....4433		35894.....4615		35123.....4802		34370.....4993		33632.....5187		
	36668.....4436		35881.....4619		35111.....4805		34357.....4996		33620.....5191		
28	36655.....4439		35868.....4622		35098.....4808		34345.....4999		33608.....5194		2
29	36641.....4442		35855.....4625		35085.....4811		34332.....5002		33596.....5197		1
	36628.....4445		35842.....4628		35073.....4815		34320.....5005		33584.....5200		
	36615.....4448		35829.....4631		35060.....4818		34308.....5009		33572.....5204		
30	36602.....4451		35816.....4634		35047.....4821		34295.....5012		33559.....5207		0
	A	B	A	B	A	B	A	B	A	B	
	154°30'		154°00'		153°30'		153°00'		152°30'		

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	27°30'		28°00'		28°30'		29°00'		29°30'		
	A	B	A	B	A	B	A	B	A	B	
0	33559.....5207		32839.....5406		32134.....5610		31443.....5818		30766.....6030		30
1	33547.....5210		32827.....5410		32122.....5614		31431.....5822		30755.....6034		29
	33535.....5214		32815.....5413		32110.....5617		31420.....5825		30744.....6038		
	33523.....5217		32803.....5417		32099.....5620		31409.....5829		30733.....6041		
2	33511.....5220		32792.....5420		32087.....5624		31397.....5832		30721.....6045		28
3	33499.....5224		32780.....5423		32076.....5627		31386.....5836		30710.....6048		27
	33487.....5227		32768.....5426		32064.....5631		31375.....5839		30699.....6052		
	33475.....5230		32756.....5430		32052.....5634		31363.....5843		30688.....6055		
4	33462.....5233		32744.....5433		32041.....5638		31352.....5846		30677.....6059		26
5	33450.....5237		32732.....5437		32029.....5641		31340.....5850		30666.....6062		25
	33438.....5240		32720.....5440		32018.....5645		31329.....5853		30655.....6066		
	33426.....5243		32709.....5443		32006.....5648		31318.....5857		30643.....6070		
6	33414.....5247		32697.....5447		31994.....5651		31306.....5860		30632.....6073		24
7	33402.....5250		32685.....5450		31983.....5655		31295.....5864		30621.....6077		23
	33390.....5253		32673.....5454		31971.....5658		31284.....5867		30610.....6080		
	33378.....5257		32661.....5457		31960.....5662		31272.....5871		30599.....6084		
8	33366.....5260		32649.....5460		31948.....5665		31261.....5874		30588.....6088		22
9	33354.....5263		32638.....5464		31936.....5669		31250.....5878		30577.....6091		21
	33342.....5266		32625.....5467		31925.....5672		31238.....5881		30566.....6095		
	33330.....5270		32614.....5470		31913.....5675		31227.....5885		30555.....6098		
10	33318.....5273		32602.....5474		31902.....5679		31216.....5888		30544.....6102		20
11	33306.....5277		32590.....5477		31890.....5682		31204.....5892		30532.....6106		19
	33293.....5280		32579.....5481		31879.....5686		31193.....5895		30521.....6109		
	33281.....5283		32567.....5484		31867.....5689		31182.....5899		30510.....6113		
12	33269.....5287		32555.....5487		31856.....5693		31170.....5902		30499.....6116		18
13	33257.....5290		32543.....5491		31844.....5696		31159.....5906		30488.....6120		17
	33245.....5293		32532.....5494		31833.....5700		31148.....5909		30477.....6124		
	33233.....5296		32520.....5498		31821.....5703		31137.....5913		30466.....6127		
14	33221.....5300		32508.....5501		31809.....5707		31125.....5917		30455.....6131		16
15	33209.....5303		32496.....5504		31798.....5710		31114.....5920		30444.....6134		15
	33197.....5306		32484.....5508		31786.....5714		31103.....5924		30433.....6138		
	33185.....5310		32473.....5511		31775.....5717		31091.....5927		30422.....6142		
16	33173.....5313		32461.....5515		31763.....5720		31080.....5931		30411.....6145		14
17	33161.....5316		32449.....5518		31752.....5724		31069.....5934		30400.....6149		13
	33149.....5320		32438.....5521		31740.....5727		31058.....5938		30389.....6153		
	33137.....5323		32426.....5525		31729.....5731		31046.....5941		30378.....6156		
18	33125.....5326		32414.....5528		31717.....5734		31035.....5945		30367.....6160		12
19	33113.....5330		32402.....5532		31706.....5738		31024.....5948		30356.....6163		11
	33101.....5333		32391.....5535		31694.....5741		31013.....5952		30345.....6167		
	33089.....5336		32379.....5538		31683.....5745		31001.....5955		30334.....6171		
20	33077.....5340		32367.....5542		31672.....5748		30990.....5959		30322.....6174		10
21	33065.....5343		32355.....5545		31660.....5752		30979.....5963		30311.....6178		9
	33054.....5346		32344.....5549		31648.....5755		30968.....5966		30300.....6181		
	33042.....5350		32332.....5552		31637.....5759		30956.....5970		30289.....6185		
22	33030.....5353		32320.....5555		31626.....5762		30945.....5973		30278.....6189		8
23	33018.....5356		32309.....5559		31614.....5766		30934.....5977		30267.....6192		7
	33006.....5360		32297.....5562		31603.....5769		30923.....5980		30256.....6196		
	32994.....5363		32285.....5566		31591.....5773		30912.....5984		30245.....6200		
24	32982.....5366		32274.....5569		31580.....5776		30900.....5988		30235.....6203		6
25	32970.....5370		32262.....5572		31569.....5780		30889.....5991		30224.....6207		5
	32958.....5373		32250.....5576		31557.....5783		30878.....5995		30213.....6210		
	32946.....5376		32239.....5579		31546.....5787		30867.....5998		30202.....6214		
26	32934.....5380		32227.....5583		31534.....5790		30856.....6002		30191.....6218		4
27	32922.....5383		32215.....5586		31523.....5794		30844.....6005		30180.....6221		3
	32910.....5386		32204.....5590		31511.....5797		30833.....6009		30169.....6225		
	32898.....5390		32192.....5593		31500.....5801		30822.....6012		30158.....6229		
28	32887.....5393		32180.....5596		31488.....5804		30811.....6016		30147.....6232		2
29	32875.....5396		32169.....5600		31477.....5808		30800.....6020		30136.....6236		1
	32863.....5400		32157.....5603		31466.....5811		30788.....6023		30125.....6240		
	32851.....5403		32145.....5607		31454.....5815		30777.....6027		30114.....6243		
30	32839.....5406		32134.....5610		31443.....5818		30766.....6030		30103.....6247		0
	A	B	A	B	A	B	A	B	A	B	
	152°00'		151°30'		151°00'		150°30'		150°00'		

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE							
	30°00'		30°30'		31°00'		
	A	B	A	B	A	B	
0	30103.....6247		29453.....6468		28816.....6693		30
1	30092.....6251		29442.....6472		28806.....6697		29
	30081.....6254		29432.....6475		28795.....6701		
	30070.....6258		29421.....6479		28785.....6705		
2	30059.....6262		29410.....6483		28774.....6709		28
3	30048.....6265		29399.....6487		28763.....6712		27
	30037.....6269		29389.....6490		28753.....6716		
	30026.....6273		29378.....6494		28743.....6720		
4	30016.....6276		29367.....6498		28732.....6724		26
5	30005.....6280		29357.....6501		28722.....6728		25
	29994.....6284		29346.....6505		28711.....6731		
	29983.....6287		29335.....6509		28701.....6735		
6	29972.....6291		29325.....6513		28690.....6739		24
7	29961.....6294		29314.....6516		28680.....6743		23
	29950.....6298		29303.....6520		28669.....6747		
	29939.....6302		29293.....6524		28659.....6750		
8	29928.....6305		29282.....6528		28648.....6754		22
9	29917.....6309		29271.....6531		28638.....6758		21
	29907.....6313		29261.....6535		28627.....6762		
	29896.....6316		29250.....6539		28617.....6766		
10	29885.....6320		29239.....6543		28606.....6770		20
11	29874.....6324		29229.....6546		28596.....6773		19
	29863.....6328		29218.....6550		28586.....6777		
	29852.....6331		29207.....6554		28575.....6781		
12	29841.....6335		29197.....6558		28565.....6785		18
13	29831.....6339		29186.....6561		28554.....6789		17
	29820.....6342		29175.....6565		28544.....6793		
	29809.....6346		29165.....6569		28533.....6796		
14	29798.....6350		29154.....6573		28523.....6800		16
15	29787.....6353		29144.....6576		28513.....6804		15
	29776.....6357		29133.....6580		28502.....6808		
	29766.....6361		29122.....6584		28492.....6812		
16	29755.....6364		29112.....6588		28481.....6815		14
17	29744.....6368		29101.....6591		28471.....6819		13
	29733.....6372		29091.....6595		28461.....6823		
	29722.....6375		29080.....6599		28450.....6827		
18	29711.....6379		29069.....6603		28440.....6831		12
19	29701.....6383		29059.....6606		28429.....6835		11
	29690.....6386		29048.....6610		28419.....6839		
	29679.....6390		29038.....6614		28409.....6842		
20	29668.....6394		29027.....6618		28398.....6846		10
21	29657.....6398		29016.....6622		28388.....6850		9
	29647.....6401		29006.....6625		28378.....6854		
	29636.....6405		28995.....6629		28367.....6858		
22	29625.....6409		28985.....6633		28357.....6862		8
23	29614.....6412		28974.....6637		28346.....6865		7
	29604.....6416		28964.....6640		28336.....6869		
	29593.....6420		28953.....6644		28326.....6873		
24	29582.....6423		28942.....6648		28315.....6877		6
25	29571.....6427		28932.....6652		28305.....6881		5
	29560.....6431		28921.....6655		28295.....6885		
	29550.....6435		28911.....6659		28284.....6889		
26	29539.....6438		28900.....6663		28274.....6893		4
27	29528.....6442		28890.....6667		28264.....6896		3
	29517.....6446		28879.....6671		28253.....6900		
	29507.....6449		28869.....6674		28243.....6904		
28	29496.....6453		28858.....6678		28233.....6908		2
29	29485.....6457		28848.....6682		28222.....6912		1
	29475.....6461		28837.....6686		28212.....6916		
	29464.....6464		28827.....6690		28202.....6920		
30	29453.....6468		28816.....6693		28191.....6923		0
	A	B	A	B	A	B	
	149°30'		149°00'		148°30'		
					148°00'		
						147°30'	

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	32°30'		33°00'		33°30'		34°00'		34°30'		
	A	B	A	B	A	B	A	B	A	B	
0	26978.....7397		26389.....7641		25811.....7889		25244.....8143		24687.....8401		30
1	26968.....7401		26379.....7645		25801.....7893		25235.....8147		24678.....8405		29
	26958.....7405		26370.....7649		25792.....7898		25225.....8151		24669.....8409		
	26949.....7409		26360.....7653		25782.....7902		25216.....8155		24660.....8414		
2	26939.....7413		26350.....7657		25773.....7906		25206.....8160		24650.....8418		28
3	26929.....7417		26340.....7661		25763.....7910		25197.....8164		24641.....8422		27
	26919.....7421		26331.....7665		25754.....7914		25188.....8168		24632.....8427		
	26909.....7425		26321.....7670		25744.....7919		25178.....8172		24623.....8431		
4	26899.....7429		26311.....7674		25735.....7923		25169.....8177		24614.....8435		26
5	26889.....7433		26302.....7678		25725.....7927		25160.....8181		24605.....8440		25
	26879.....7437		26292.....7682		25716.....7931		25150.....8185		24595.....8444		
	26869.....7441		26282.....7686		25706.....7935		25141.....8189		24586.....8448		
6	26860.....7445		26273.....7690		25697.....7940		25132.....8194		24577.....8453		24
7	26850.....7449		26263.....7694		25687.....7944		25122.....8198		24568.....8457		23
	26840.....7453		26253.....7698		25678.....7948		25113.....8202		24559.....8461		
	26830.....7458		26244.....7702		25668.....7952		25104.....8207		24550.....8466		
8	26820.....7462		26234.....7707		25659.....7956		25094.....8211		24540.....8470		22
9	26810.....7466		26224.....7711		25649.....7961		25085.....8215		24531.....8475		21
	26800.....7470		26214.....7715		25640.....7965		25076.....8219		24522.....8479		
	26790.....7474		26205.....7719		25630.....7969		25066.....8224		24513.....8483		
10	26781.....7478		26195.....7723		25621.....7973		25057.....8228		24504.....8488		20
11	26771.....7482		26185.....7727		25611.....7977		25048.....8232		24495.....8492		19
	26761.....7486		26175.....7731		25602.....7982		25038.....8237		24486.....8496		
	26751.....7490		26166.....7736		25592.....7986		25029.....8241		24477.....8501		
12	26741.....7494		26157.....7740		25583.....7990		25020.....8245		24467.....8505		18
13	26731.....7498		26147.....7744		25573.....7994		25011.....8249		24458.....8510		17
	26722.....7502		26137.....7748		25564.....7998		25001.....8254		24449.....8514		
	26712.....7506		26128.....7752		25554.....8003		24992.....8258		24440.....8518		
14	26702.....7510		26118.....7756		25545.....8007		24983.....8262		24431.....8523		16
15	26692.....7514		26108.....7760		25536.....8011		24973.....8267		24422.....8527		15
	26682.....7518		26099.....7764		25526.....8015		24964.....8271		24413.....8531		
	26672.....7522		26089.....7769		25517.....8020		24955.....8275		24404.....8536		
16	26663.....7526		26079.....7773		25507.....8024		24946.....8280		24395.....8540		14
17	26653.....7531		26070.....7777		25498.....8028		24936.....8284		24385.....8545		13
	26643.....7535		26060.....7781		25488.....8032		24927.....8288		24376.....8549		
	26633.....7539		26051.....7785		25479.....8037		24918.....8292		24367.....8553		
18	26623.....7543		26041.....7789		25469.....8041		24909.....8297		24358.....8558		12
19	26614.....7547		26031.....7793		25460.....8045		24899.....8301		24349.....8562		11
	26604.....7551		26022.....7798		25451.....8049		24890.....8305		24340.....8567		
	26594.....7555		26012.....7802		25441.....8053		24881.....8310		24331.....8571		
20	26584.....7559		26002.....7806		25432.....8058		24872.....8314		24322.....8575		10
21	26574.....7563		25993.....7810		25422.....8062		24862.....8318		24313.....8580		9
	26565.....7567		25983.....7814		25413.....8066		24853.....8323		24304.....8584		
	26555.....7571		25974.....7818		25403.....8070		24844.....8327		24295.....8589		
22	26545.....7575		25964.....7823		25394.....8075		24835.....8331		24286.....8593		8
23	26535.....7579		25954.....7827		25385.....8079		24825.....8336		24276.....8597		7
	26526.....7584		25945.....7831		25375.....8083		24816.....8340		24267.....8602		
	26516.....7588		25935.....7835		25366.....8087		24807.....8344		24258.....8606		
24	26506.....7592		25926.....7839		25356.....8091		24798.....8349		24249.....8611		6
25	26496.....7596		25916.....7843		25347.....8096		24788.....8353		24240.....8615		5
	26486.....7600		25907.....7848		25338.....8100		24779.....8357		24231.....8619		
	26477.....7604		25897.....7852		25328.....8104		24770.....8362		24222.....8624		
26	26467.....7608		25887.....7856		25319.....8108		24761.....8366		24213.....8628		4
27	26457.....7612		25878.....7860		25309.....8113		24752.....8370		24204.....8633		3
	26447.....7616		25868.....7864		25300.....8117		24742.....8375		24195.....8637		
	26438.....7620		25859.....7868		25291.....8121		24733.....8379		24186.....8641		
28	26428.....7625		25849.....7873		25281.....8125		24724.....8383		24177.....8646		2
29	26418.....7629		25840.....7877		25272.....8130		24715.....8388		24168.....8650		1
	26409.....7633		25830.....7881		25263.....8134		24706.....8392		24159.....8655		
	26399.....7637		25821.....7885		25253.....8138		24696.....8396		24150.....8659		
30	26389.....7641		25811.....7889		25244.....8143		24687.....8401		24141.....8663		0
	A	B	A	B	A	B	A	B	A	B	
	147°00'		146°30'		146°00'		145°30'		145°00'		

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

	35°00'		35°30'		36°00'		36°30'		37°00'		
	A	B	A	B	A	B	A	B	A	B	
0	24141.....8663		23605.....8931		23078.....9204		22561.....9482		22054.....9765		30
1	24132.....8668		23596.....8936		23069.....9209		22553.....9487		22045.....9770		29
	24123.....8672		23587.....8940		23061.....9213		22544.....9492		22037.....9775		
	24114.....8677		23578.....8945		23052.....9218		22536.....9496		22029.....9779		
2	24105.....8681		23569.....8949		23043.....9223		22527.....9501		22020.....9784		28
3	24096.....8686		23560.....8954		23035.....9227		22519.....9505		22012.....9789		27
	24087.....8690		23551.....8958		23026.....9232		22510.....9510		22003.....9794		
	24078.....8694		23543.....8963		23017.....9236		22501.....9515		21995.....9798		
4	24069.....8699		23534.....8967		23009.....9241		22493.....9520		21987.....9803		26
5	24060.....8703		23525.....8972		23000.....9246		22484.....9524		21978.....9808		25
	24051.....8708		23516.....8976		22991.....9250		22476.....9529		21970.....9813		
	24042.....8712		23507.....8981		22983.....9255		22467.....9534		21962.....9818		
6	24033.....8717		23498.....8986		22974.....9259		22459.....9538		21953.....9822		24
7	24024.....8721		23490.....8990		22965.....9264		22450.....9543		21945.....9827		23
	24015.....8726		23481.....8995		22957.....9269		22442.....9548		21937.....9832		
	24006.....8730		23472.....8999		22948.....9273		22433.....9552		21928.....9837		
8	23997.....8734		23463.....9004		22939.....9278		22425.....9557		21920.....9841		22
9	23988.....8739		23454.....9008		22931.....9282		22416.....9562		21912.....9846		21
	23979.....8743		23446.....9013		22922.....9287		22408.....9566		21903.....9851		
	23970.....8748		23437.....9017		22913.....9292		22399.....9571		21895.....9856		
10	23961.....8752		23428.....9022		22905.....9296		22391.....9576		21887.....9861		20
11	23952.....8757		23419.....9026		22896.....9301		22382.....9581		21878.....9865		19
	23943.....8761		23410.....9031		22887.....9305		22374.....9585		21870.....9870		
	23934.....8766		23402.....9035		22879.....9310		22366.....9590		21862.....9875		
12	23925.....8770		23393.....9040		22870.....9315		22357.....9595		21853.....9880		18
13	23916.....8775		23384.....9044		22862.....9319		22349.....9599		21845.....9885		17
	23907.....8779		23375.....9049		22853.....9324		22340.....9604		21837.....9889		
	23898.....8783		23366.....9054		22844.....9329		22332.....9609		21828.....9894		
14	23889.....8788		23358.....9058		22836.....9333		22323.....9614		21820.....9899		16
15	23880.....8792		23349.....9063		22827.....9338		22315.....9618		21812.....9904		15
	23871.....8797		23340.....9067		22818.....9342		22306.....9623		21803.....9909		
	23863.....8801		23331.....9072		22810.....9347		22298.....9628		21795.....9913		
16	23854.....8806		23323.....9076		22801.....9352		22289.....9632		21787.....9918		14
17	23845.....8810		23314.....9081		22793.....9356		22281.....9637		21778.....9923		13
	23836.....8815		23305.....9085		22784.....9361		22272.....9642		21770.....9928		
	23827.....8819		23296.....9090		22775.....9366		22264.....9647		21762.....9933		
18	23818.....8824		23288.....9094		22767.....9370		22256.....9651		21754.....9937		12
19	23809.....8828		23279.....9099		22758.....9375		22247.....9656		21745.....9942		11
	23800.....8833		23270.....9104		22750.....9380		22239.....9661		21737.....9947		
	23791.....8837		23261.....9108		22741.....9384		22230.....9665		21729.....9952		
20	23782.....8842		23252.....9113		22732.....9389		22222.....9670		21720.....9957		10
21	23773.....8846		23244.....9117		22724.....9394		22213.....9675		21712.....9962		9
	23764.....8850		23235.....9122		22715.....9398		22205.....9680		21704.....9966		
	23755.....8855		23226.....9126		22707.....9403		22197.....9684		21696.....9971		
22	23747.....8859		23218.....9131		22698.....9407		22188.....9689		21687.....9976		8
23	23738.....8864		23209.....9136		22690.....9412		22180.....9694		21679.....9981		7
	23729.....8868		23200.....9140		22681.....9417		22171.....9699		21671.....9986		
	23720.....8873		23191.....9145		22672.....9421		22168.....9703		21662.....9990		
24	23711.....8877		23183.....9149		22664.....9426		22154.....9708		21654.....9995		6
25	23702.....8882		23174.....9154		22655.....9431		22146.....9713		21646.....10000		5
	23693.....8886		23165.....9158		22647.....9435		22138.....9718		21638.....10005		
	23684.....8891		23156.....9163		22638.....9440		22129.....9722		21629.....10010		
26	23675.....8895		23148.....9168		22630.....9445		22121.....9727		21621.....10015		4
27	23667.....8900		23139.....9172		22621.....9449		22112.....9732		21613.....10019		3
	23658.....8904		23130.....9177		22612.....9454		22104.....9737		21605.....10024		
	23649.....8909		23122.....9181		22604.....9459		22096.....9741		21596.....10029		
28	23640.....8913		23113.....9186		22595.....9463		22087.....9746		21588.....10034		2
29	23631.....8918		23104.....9190		22587.....9468		22079.....9751		21580.....10039		1
	23622.....8922		23095.....9195		22578.....9473		22070.....9756		21572.....10044		
	23613.....8927		23087.....9200		22570.....9477		22062.....9760		21563.....10049		
30	23605.....8931		23078.....9204		22561.....9482		22054.....9765		21555.....10053		0
	A	B	A	B	A	B	A	B	A	B	
	144°30'		144°00'		143°30'		143°00'		142°30'		

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	37°30'		38°00'		38°30'		39°00'		39°30'		
	A	B	A	B	A	B	A	B	A	B	
0	21555....10053		21066....10347		20585....10646		20113....10950		19649....11259		30
1	21547....10058		21058....10352		20577....10651		20105....10955		19641....11265		29
	21539....10063		21050....10357		20569....10656		20097....10960		19634....11270		
	21531....10068		21042....10362		20561....10661		20089....10965		19626....11275		
2	21522....10073		21033....10367		20553....10666		20082....10970		19618....11280		28
3	21514....10078		21025....10372		20545....10671		20074....10975		19611....11285		27
	21506....10082		21017....10376		20537....10676		20066....10980		19603....11291		
	21498....10087		21009....10381		20529....10681		20058....10986		19595....11296		
4	21489....10092		21001....10386		20522....10686		20050....10991		19588....11301		26
5	21481....10097		20993....10391		20514....10691		20043....10996		19580....11306		25
	21473....10102		20985....10396		20506....10696		20035....11001		19572....11311		
	21465....10107		20977....10401		20498....10701		20027....11006		19565....11317		
6	21457....10112		20969....10406		20490....10706		20019....11011		19557....11322		24
7	21448....10116		20961....10411		20482....10711		20012....11016		19549....11327		23
	21440....10121		20953....10416		20474....10716		20004....11021		19541....11332		
	21432....10126		20945....10421		20466....10721		19996....11027		19534....11338		
8	21424....10131		20937....10426		20458....10726		19988....11032		19527....11343		22
9	21416....10136		20929....10431		20450....10731		19980....11037		19519....11348		21
	21407....10141		20921....10436		20442....10736		19973....11042		19511....11353		
	21399....10146		20913....10441		20435....10741		19965....11047		19504....11359		
10	21391....10151		20905....10446		20427....10746		19957....11052		19496....11364		20
11	21383....10155		20897....10451		20419....10751		19949....11057		19488....11369		19
	21375....10160		20888....10456		20411....10756		19942....11063		19481....11374		
	21367....10165		20880....10461		20403....10761		19934....11068		19473....11380		
12	21358....10170		20872....10466		20395....10767		19926....11073		19466....11385		18
13	21350....10175		20864....10471		20387....10772		19919....11078		19458....11390		17
	21342....10180		20856....10476		20379....10777		19911....11083		19450....11395		
	21334....10185		20848....10481		20371....10782		19903....11088		19443....11400		
14	21326....10190		20840....10486		20364....10787		19895....11094		19435....11406		16
15	21318....10195		20832....10491		20356....10792		19888....11099		19428....11411		15
	21309....10199		20824....10496		20348....10797		19880....11104		19420....11416		
	21301....10204		20816....10500		20340....10802		19872....11109		19412....11422		
16	21293....10209		20808....10505		20332....10807		19864....11114		19405....11427		14
17	21285....10214		20800....10510		20324....10812		19857....11119		19397....11432		13
	21277....10219		20792....10515		20316....10817		19849....11124		19390....11437		
	21269....10224		20784....10520		20309....10822		19841....11130		19382....11443		
18	21260....10229		20776....10525		20301....10827		19834....11135		19375....11448		12
19	21252....10234		20768....10530		20293....10832		19826....11140		19367....11453		11
	21244....10239		20760....10535		20285....10838		19818....11145		19359....11458		
	21236....10243		20752....10540		20277....10843		19810....11150		19352....11464		
20	21228....10248		20744....10545		20269....10848		19803....11156		19344....11469		10
21	21220....10253		20736....10550		20261....10853		19795....11161		19337....11474		9
	21212....10258		20728....10555		20254....10858		19787....11166		19329....11479		
	21204....10263		20720....10560		20246....10863		19779....11171		19321....11485		
22	21195....10268		20712....10565		20238....10868		19772....11176		19314....11490		8
23	21187....10273		20704....10570		20230....10873		19764....11181		19306....11495		7
	21179....10278		20696....10575		20222....10878		19756....11187		19299....11501		
	21171....10283		20688....10580		20214....10883		19749....11192		19291....11506		
24	21163....10288		20680....10585		20207....10888		19741....11197		19284....11511		6
25	21155....10293		20672....10590		20199....10894		19733....11202		19276....11516		5
	21147....10298		20665....10595		20191....10899		19726....11207		19269....11522		
	21139....10302		20657....10600		20183....10904		19718....11213		19261....11527		
26	21131....10307		20649....10605		20175....10909		19710....11218		19253....11532		4
27	21122....10312		20641....10610		20167....10914		19703....11223		19246....11537		3
	21114....10317		20633....10615		20160....10919		19695....11228		19238....11543		
	21106....10322		20625....10620		20152....10924		19687....11233		19231....11548		
28	21098....10327		20617....10625		20144....10929		19680....11239		19223....11553		2
29	21090....10332		20609....10630		20136....10934		19672....11244		19216....11559		1
	21082....10337		20601....10635		20128....10939		19664....11249		19208....11564		
	21074....10342		20593....10640		20121....10945		19657....11254		19201....11569		
30	21066....10347		20585....10646		20113....10950		19649....11259		19193....11575		0
	A	B	A	B	A	B	A	B	A	B	
	142°00'		141°30'		141°00'		140°30'		140°00'		

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

	40°00'		40°30'		41°00'		41°30'		42°00'		
	A	B	A	B	A	B	A	B	A	B	
0	19193....	11575	18746....	11895	18306....	12222	17873....	12554	17449....	12893	30
1	19186....	11580	18738....	11901	18298....	12228	17866....	12560	17442....	12898	29
	19178....	11585	18731....	11906	18291....	12233	17859....	12566	17435....	12904	
	19171....	11590	18723....	11912	18284....	12238	17852....	12571	17428....	12910	
2	19163....	11596	18716....	11917	18277....	12244	17845....	12577	17421....	12915	28
3	19156....	11601	18709....	11922	18269....	12249	17838....	12582	17414....	12921	27
	19148....	11606	18701....	11928	18262....	12255	17831....	12588	17407....	12927	
	19141....	11612	18694....	11933	18255....	12260	17824....	12593	17400....	12932	
4	19133....	11617	18686....	11939	18248....	12266	17816....	12599	17393....	12938	26
5	19126....	11622	18679....	11944	19240....	12271	17809....	12605	17286....	12944	25
	19118....	11628	18672....	11949	18233....	12277	17802....	12610	17379....	12950	
	19111....	11633	18664....	11955	18226....	12282	17795....	12616	17372....	12955	
6	19103....	11638	18657....	11960	18219....	12288	17788....	12622	17365....	12961	24
7	19096....	11644	18650....	11966	18211....	12293	17781....	12627	17358....	12967	23
	19088....	11649	18642....	11971	18204....	12299	17774....	12633	17351....	12972	
	19081....	11654	18635....	11977	18197....	12305	17767....	12638	17344....	12978	
8	19073....	11660	18627....	11982	18190....	12310	17760....	12644	17337....	12984	22
9	19066....	11665	18620....	11987	18182....	12316	17752....	12650	17330....	12990	21
	19058....	11670	18613....	11993	18175....	12321	17745....	12655	17323....	12995	
	19051....	11676	18605....	11998	18168....	12327	17738....	12661	17316....	13001	
10	19043....	11681	18598....	12004	18161....	12332	17731....	12667	17309....	13007	20
11	19036....	11686	18591....	12009	18154....	12338	17724....	12672	17302....	13012	19
	19028....	11692	18583....	12014	18146....	12343	17717....	12678	17295....	13018	
	19021....	11697	18576....	12020	18139....	12349	17710....	12683	17288....	13024	
12	19013....	11702	18569....	12025	18132....	12354	17703....	12689	17281....	13030	18
13	19006....	11708	18561....	12031	18125....	12360	17696....	12695	17274....	13035	17
	18998....	11713	18554....	12036	18117....	12365	17689....	12700	17267....	13041	
	18991....	11718	18547....	12042	18110....	12371	17681....	12706	17260....	13047	
14	18983....	11724	18539....	12047	18103....	12376	17674....	12711	17253....	13053	16
15	18976....	11729	18532....	12053	18096....	12382	17667....	12717	17246....	13058	15
	18968....	11734	18525....	12058	18089....	12387	17660....	12723	17239....	13064	
	18961....	11740	18517....	12063	18081....	12393	17653....	12728	17232....	13070	
16	18953....	11745	18510....	12069	18074....	12398	17646....	12734	17225....	13075	14
17	18946....	11750	18503....	12074	18067....	12404	17639....	12740	17218....	13081	13
	18939....	11756	18495....	12080	18060....	12410	17632....	12745	17212....	13087	
	18931....	11761	18488....	12085	18053....	12415	17625....	12751	17205....	13093	
18	18924....	11766	18481....	12091	18045....	12421	17618....	12757	17198....	13098	12
19	18916....	11772	18473....	12096	18038....	12426	17611....	12762	17191....	13104	11
	18909....	11777	18466....	12102	18031....	12432	17604....	12768	17184....	13110	
	18901....	11782	18459....	12107	18024....	12437	17597....	12774	17177....	13116	
20	18894....	11788	18451....	12112	18017....	12443	17590....	12779	17170....	13121	10
21	18886....	11793	18444....	12118	18010....	12448	17583....	12785	17163....	13127	9
	18879....	11799	18437....	12123	18002....	12454	17575....	12790	17156....	13133	
	18872....	11804	18429....	12129	17995....	12460	17568....	12796	17149....	13139	
22	18864....	11809	18422....	12134	17988....	12465	17561....	12802	17142....	13144	8
23	18857....	11815	18415....	12140	17981....	12471	17554....	12807	17135....	13150	7
	18849....	11820	18408....	12145	17974....	12476	17547....	12813	17128....	13156	
	18842....	11825	18400....	12151	17966....	12482	17540....	12819	17121....	13162	
24	18834....	11831	18393....	12156	17959....	12467	17533....	12824	17114....	13168	6
25	18827....	11836	18386....	12162	17952....	12493	17526....	12830	17108....	13173	5
	18820....	11842	18378....	12167	17945....	12499	17519....	12836	17107....	13179	
	18812....	11847	18371....	12173	17938....	12504	17512....	12841	17094....	13185	
26	18805....	11852	18364....	12178	17931....	12510	17505....	12847	17087....	13191	4
27	18797....	11858	18357....	12184	17924....	12515	17498....	12853	17080....	13196	3
	18790....	11863	18349....	12189	17916....	12521	17491....	12859	17073....	13202	
	18783....	11868	18342....	12195	17909....	12526	17484....	12864	17066....	13208	
28	18775....	11874	18335....	12200	17902....	12532	17477....	12870	17059....	13214	2
29	18768....	11879	18327....	12205	17895....	12538	17470....	12876	17052....	13220	1
	18760....	11885	18320....	12211	17888....	12543	17463....	12881	17046....	13225	
	18753....	11890	18313....	12216	17881....	12549	17456....	12887	17039....	13231	
30	18746....	11895	18306....	12222	17873....	12554	17449....	12893	17032....	13237	0
	A	B	A	B	A	B	A	B	A	B	
	139°30'		139°00'		138°30'		138°00'		137°30'		

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	42°30'		43°00'		43°30'		44°00'		44°30'		
	A	B	A	B	A	B	A	B	A	B	
0	17032.....13237		16622.....13587		16219.....13944		15823.....14307		15434.....14676		30
1	17025.....13243		16615.....13593		16212.....13950		15816.....14313		15427.....14682		29
	17018.....13248		16608.....13599		16205.....13956		15810.....14319		15421.....14688		
	17011.....13254		16601.....13605		16199.....13962		15803.....14325		15414.....14694		
2	17004.....13260		16595.....13611		16192.....13968		15797.....14331		15408.....14701		28
3	16997.....13266		16588.....13617		16186.....13974		15790.....14337		15402.....14707		27
	16990.....13272		16581.....13623		16179.....13980		15784.....14343		15395.....14713		
	16983.....13277		16574.....13628		16172.....13986		15777.....14349		15389.....14719		
4	16977.....13283		16567.....13634		16166.....13992		15771.....14355		15382.....14726		26
5	16970.....13289		16561.....13640		16159.....13998		15764.....14362		15376.....14732		25
	16963.....13295		16554.....13646		16152.....14004		15758.....14368		15370.....14738		
	16956.....13301		16547.....13652		16146.....14010		15751.....14374		15363.....14744		
6	16949.....13306		16540.....13658		16139.....14016		15744.....14380		15357.....14750		24
7	16942.....13312		16534.....13664		16132.....14022		15738.....14386		15350.....14757		23
	16935.....13318		16527.....13670		16126.....14028		15731.....14392		15344.....14763		
	16928.....13324		16520.....13676		16119.....14034		15725.....14398		15338.....14769		
8	16922.....13330		16513.....13682		16112.....14040		15718.....14404		15331.....14775		22
9	16915.....13336		16507.....13688		16106.....14046		15712.....14411		15325.....14782		21
	16908.....13341		16500.....13694		16099.....14052		15705.....14417		15318.....14788		
	16901.....13347		16493.....13700		16093.....14058		15699.....14423		15312.....14794		
10	16894.....13353		16487.....13705		16086.....14064		15692.....14429		15306.....14800		20
11	16887.....13359		16480.....13711		16079.....14070		15686.....14435		15299.....14807		19
	16880.....13365		16473.....13717		16073.....14076		15679.....14441		15293.....14813		
	16874.....13370		16466.....13723		16066.....14082		15673.....14447		15286.....14819		
12	16867.....13376		16460.....13729		16060.....14088		15666.....14453		15280.....14825		18
13	16860.....13382		16453.....13735		16053.....14094		15660.....14460		15274.....14831		17
	16853.....13388		16446.....13741		16046.....14100		15653.....14466		15267.....14838		
	16846.....13394		16439.....13747		16040.....14106		15647.....14472		15261.....14844		
14	16839.....13400		16433.....13753		16033.....14112		15640.....14478		15255.....14850		16
15	16833.....13405		16426.....13759		16027.....14118		15634.....14484		15248.....14857		15
	16826.....13411		16419.....13765		16020.....14124		15627.....14490		15242.....14863		
	16819.....13417		16413.....13771		16013.....14130		15621.....14496		15235.....14869		
16	16812.....13423		16406.....13777		16007.....14136		15614.....14503		15229.....14875		14
17	16805.....13429		16399.....13783		16000.....14142		15608.....14509		15223.....14882		13
	16798.....13435		16392.....13789		15994.....14149		15602.....14515		15216.....14888		
	16792.....13440		16386.....13794		15987.....14155		15595.....14521		15210.....14894		
18	16785.....13446		16379.....13800		15980.....14161		15589.....14527		15204.....14900		12
19	16778.....13452		16372.....13806		15974.....14167		15582.....14533		15197.....14907		11
	16771.....13458		16366.....13812		15967.....14173		15576.....14540		15191.....14913		
	16764.....13464		16359.....13818		15961.....14179		15569.....14546		15184.....14919		
20	16757.....13470		16352.....13824		15954.....14185		15563.....14552		15178.....14925		10
21	16751.....13476		16346.....13830		15947.....14191		15556.....14558		15172.....14932		9
	16744.....13481		16339.....13836		15941.....14197		15550.....14564		15165.....14938		
	16737.....13487		16332.....13842		15934.....14203		15543.....14570		15159.....14944		
22	16730.....13493		16325.....13848		15928.....14209		15537.....14577		15153.....14951		8
23	16723.....13499		16319.....13854		15921.....14215		15530.....14583		15146.....14957		7
	16717.....13505		16312.....13860		15915.....14221		15524.....14589		15140.....14963		
	16710.....13511		16305.....13866		15908.....14227		15517.....14595		15134.....14969		
24	16703.....13517		16299.....13872		15901.....14233		15511.....14601		15127.....14976		6
25	16696.....13523		16292.....13878		15895.....14240		15505.....14608		15121.....14982		5
	16689.....13528		16285.....13884		15888.....14246		15498.....14614		15115.....14988		
	16683.....13534		16279.....13890		15882.....14252		15492.....14620		15108.....14995		
26	16676.....13540		16272.....13896		15875.....14258		15485.....14626		15102.....15001		4
27	16669.....13546		16265.....13902		15869.....14264		15479.....14632		15096.....15007		3
	16662.....13552		16259.....13908		15862.....14270		15472.....14639		15089.....15014		
	16656.....13558		16252.....13914		15856.....14276		15466.....14645		15083.....15020		
28	16649.....13564		16245.....13920		15849.....14282		15459.....14651		15077.....15026		2
29	16642.....13570		16239.....13926		15842.....14288		15453.....14657		15070.....15033		1
	16635.....13575		16232.....13932		15836.....14294		15447.....14663		15064.....15039		
	16628.....13581		16225.....13938		15829.....14300		15440.....14670		15058.....15045		
30	16622.....13587		16219.....13944		15823.....14307		15434.....14676		15051.....15051		0
	A	B	A	B	A	B	A	B	A	B	
	137°00'		136°30'		136°00'		135°30'		135°00'		

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

	45°00'		45°30'		46°00'		46°30'		47°00'		
	A	B	A	B	A	B	A	B	A	B	
0	15051.....	15051	14676.....	15434	14307.....	15823	13944.....	16219	13587.....	16622	30
1	15045.....	15058	14670.....	15440	14300.....	15829	13938.....	16225	13581.....	16628	29
	15039.....	15064	14663.....	15447	14294.....	15836	13932.....	16232	13575.....	16635	
	15033.....	15070	14657.....	15453	14288.....	15842	13926.....	16239	13570.....	16642	
2	15026.....	15077	14651.....	15459	14282.....	15849	13920.....	16245	13564.....	16649	28
3	15020.....	15083	14645.....	15466	14276.....	15856	13914.....	16252	13558.....	16656	27
	15014.....	15089	14639.....	15472	14270.....	15862	13908.....	16259	13552.....	16662	
	15007.....	15096	14632.....	15479	14264.....	15869	13902.....	16265	13546.....	16669	
4	15001.....	15102	14626.....	15485	14258.....	15875	13896.....	16272	13540.....	16676	26
5	14995.....	15108	14620.....	15492	14252.....	15882	13890.....	16279	13534.....	16683	25
	14988.....	15115	14614.....	15498	14246.....	15888	13884.....	16285	13528.....	16689	
	14982.....	15121	14608.....	15505	14240.....	15895	13878.....	16292	13523.....	16696	
6	14976.....	15127	14601.....	15511	14233.....	15901	13872.....	16299	13517.....	16703	24
7	14969.....	15134	14595.....	15517	14227.....	15908	13866.....	16305	13511.....	16710	23
	14963.....	15140	14589.....	15524	14221.....	15915	13860.....	16312	13505.....	16717	
	14957.....	15146	14583.....	15530	14215.....	15921	13854.....	16319	13499.....	16723	
8	14951.....	15153	14577.....	15537	14209.....	15928	13848.....	16325	13493.....	16730	22
9	14944.....	15159	14570.....	15543	14203.....	15934	13842.....	16332	13487.....	16737	21
	14938.....	15165	14564.....	15550	14197.....	15941	13836.....	16339	13481.....	16744	
	14932.....	15172	14558.....	15556	14191.....	15947	13830.....	16346	13476.....	16751	
10	14925.....	15178	14552.....	15563	14185.....	15954	13824.....	16352	13470.....	16757	20
11	14919.....	15184	14546.....	15569	14179.....	15961	13818.....	16359	13464.....	16764	19
	14913.....	15191	14540.....	15576	14173.....	15967	13812.....	16366	13458.....	16771	
	14907.....	15197	14533.....	15582	14167.....	15974	13806.....	16372	13452.....	16778	
12	14900.....	15204	14527.....	15589	14161.....	15980	13800.....	16379	13446.....	16785	18
13	14894.....	15210	14521.....	15595	14155.....	15987	13794.....	16386	13440.....	16792	17
	14888.....	15216	14515.....	15602	14149.....	15994	13788.....	16392	13435.....	16798	
	14882.....	15223	14509.....	15608	14142.....	16000	13783.....	16399	13429.....	16805	
14	14875.....	15229	14503.....	15614	14136.....	16007	13777.....	16406	13423.....	16812	16
15	14869.....	15235	14496.....	15621	14130.....	16013	13771.....	16413	13417.....	16819	15
	14863.....	15242	14490.....	15627	14124.....	16020	13765.....	16419	13411.....	16826	
	14857.....	15248	14484.....	15634	14118.....	16027	13759.....	16426	13405.....	16833	
16	14850.....	15255	14478.....	15640	14112.....	16033	13753.....	16433	13400.....	16839	14
17	14844.....	15261	14472.....	15647	14106.....	16040	13747.....	16439	13394.....	16846	13
	14838.....	15267	14466.....	15653	14100.....	16046	13741.....	16446	13388.....	16853	
	14831.....	15274	14460.....	15660	14094.....	16053	13735.....	16453	13382.....	16860	
18	14825.....	15280	14453.....	15666	14088.....	16060	13729.....	16460	13376.....	16867	12
19	14819.....	15286	14447.....	15673	14082.....	16066	13723.....	16466	13370.....	16874	11
	14813.....	15293	14441.....	15679	14076.....	16073	13717.....	16473	13365.....	16880	
	14807.....	15299	14435.....	15686	14070.....	16079	13711.....	16480	13359.....	16887	
20	14800.....	15306	14429.....	15692	14064.....	16086	13705.....	16487	13353.....	16894	10
21	14794.....	15312	14423.....	15699	14058.....	16093	13699.....	16493	13347.....	16901	9
	14788.....	15318	14417.....	15705	14052.....	16099	13694.....	16500	13341.....	16908	
	14782.....	15325	14411.....	15712	14046.....	16105	13688.....	16507	13336.....	16915	
22	14775.....	15331	14404.....	15718	14040.....	16112	13682.....	16513	13330.....	16922	8
23	14769.....	15338	14398.....	15725	14034.....	16119	13676.....	16520	13324.....	16928	7
	14763.....	15344	14392.....	15731	14028.....	16126	13670.....	16527	13318.....	16935	
	14757.....	15350	14386.....	15738	14022.....	16132	13664.....	16534	13312.....	16942	
24	14750.....	15357	14380.....	15744	14016.....	16139	13658.....	16540	13306.....	16949	6
25	14744.....	15363	14374.....	15751	14010.....	16146	13652.....	16547	13301.....	16956	5
	14738.....	15370	14368.....	15758	14004.....	16152	13646.....	16554	13295.....	16963	
	14732.....	15376	14362.....	15764	13998.....	16159	13640.....	16561	13289.....	16970	
26	14725.....	15382	14355.....	15771	13992.....	16166	13634.....	16567	13283.....	16977	4
27	14719.....	15389	14349.....	15777	13986.....	16172	13628.....	16574	13277.....	16983	3
	14713.....	15395	14343.....	15784	13980.....	16179	13623.....	16581	13272.....	16990	
	14707.....	15402	14337.....	15790	13974.....	16185	13617.....	16588	13266.....	16997	
28	14701.....	15408	14331.....	15797	13968.....	16192	13611.....	16595	13260.....	17004	2
29	14694.....	15414	14325.....	15803	13962.....	16199	13605.....	16601	13254.....	17011	1
	14688.....	15421	14319.....	15810	13956.....	16205	13599.....	16608	13248.....	17018	
30	14682.....	15427	14313.....	15816	13950.....	16212	13593.....	16615	13243.....	17025	0
	14676.....	15434	14307.....	15823	13944.....	16219	13587.....	16622	13237.....	17032	
	A	B	A	B	A	B	A	B	A	B	
	134°30'		134°00'		133°30'		133°00'		132°30'		

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	47°30'		48°00'		48°30'		49°00'		49°30'		
	A	B	A	B	A	B	A	B	A	B	
0	13237....	17032	12893....	17449	12554....	17873	12222....	18306	11895....	18746	30
1	13231....	17039	12887....	17456	12549....	17881	12216....	18313	11890....	18753	29
	13225....	17045	12881....	17463	12543....	17888	12211....	18320	11885....	18760	
	13220....	17052	12876....	17470	12538....	17895	12205....	18327	11879....	18768	
2	13214....	17059	12870....	17477	12532....	17902	12200....	18335	11874....	18775	28
3	13208....	17066	12864....	17484	12526....	17909	12195....	18342	11868....	18783	27
	13202....	17073	12859....	17491	12521....	17916	12189....	18349	11863....	18790	
	13196....	17080	12853....	17498	12515....	17924	12184....	18357	11858....	18797	
4	13191....	17087	12847....	17505	12510....	17931	12178....	18364	11852....	18805	26
5	13185....	17094	12841....	17512	12504....	17938	12173....	18371	11847....	18812	25
	13179....	17101	12836....	17519	12499....	17945	12167....	18378	11842....	18820	
	13173....	17108	12830....	17526	12493....	17952	12162....	18386	11836....	18827	
6	13168....	17114	12824....	17533	12487....	17959	12156....	18393	11831....	18834	24
7	13162....	17121	12819....	17540	12482....	17966	12151....	18400	11825....	18842	23
	13156....	17128	12813....	17547	12476....	17974	12145....	18408	11820....	18849	
	13150....	17135	12807....	17554	12471....	17981	12140....	18415	11815....	18857	
8	13144....	17142	12802....	17561	12465....	17988	12134....	18422	11809....	18864	22
9	13139....	17149	12796....	17568	12460....	17995	12129....	18429	11804....	18872	21
	13133....	17156	12790....	17576	12454....	18002	12123....	18437	11799....	18879	
	13127....	17163	12785....	17583	12448....	18010	12118....	18444	11793....	18886	
10	13121....	17170	12779....	17590	12443....	18017	12112....	18451	11788....	18894	20
11	13116....	17177	12774....	17597	12437....	18024	12107....	18459	11782....	18901	19
	13110....	17184	12768....	17604	12432....	18031	12102....	18466	11777....	18909	
	13104....	17191	12762....	17611	12426....	18038	12096....	18473	11772....	18916	
12	13098....	17198	12757....	17618	12421....	18045	12091....	18481	11766....	18924	18
13	13093....	17205	12751....	17625	12415....	18053	12085....	18488	11761....	18931	17
	13087....	17212	12745....	17632	12410....	18060	12080....	18495	11756....	18939	
	13081....	17218	12740....	17639	12404....	18067	12074....	18503	11750....	18946	
14	13075....	17225	12734....	17646	12398....	18074	12069....	18510	11745....	18953	16
15	13070....	17232	12728....	17653	12393....	18081	12063....	18517	11740....	18961	15
	13064....	17239	12723....	17660	12387....	18089	12058....	18525	11734....	18968	
	13058....	17246	12717....	17667	12382....	18096	12053....	18532	11729....	18976	
16	13053....	17253	12711....	17674	12376....	18103	12047....	18539	11724....	18983	14
17	13047....	17260	12706....	17681	12371....	18110	12042....	18547	11718....	18991	13
	13041....	17267	12700....	17689	12365....	18117	12036....	18554	11713....	18998	
	13035....	17274	12695....	17696	12360....	18125	12031....	18561	11708....	19006	
18	13030....	17281	12689....	17703	12354....	18132	12025....	18569	11702....	19013	12
19	13024....	17288	12683....	17710	12349....	18139	12020....	18576	11697....	19021	11
	13018....	17295	12678....	17717	12343....	18146	12014....	18583	11692....	19028	
	13012....	17302	12672....	17724	12338....	18154	12009....	18591	11686....	19036	
20	13007....	17309	12666....	17731	12332....	18161	12004....	18598	11681....	19043	10
21	13001....	17316	12661....	17738	12327....	18168	11998....	18605	11676....	19051	9
	12995....	17323	12655....	17745	12321....	18175	11993....	18613	11670....	19058	
	12990....	17330	12650....	17752	12316....	18182	11987....	18620	11665....	19066	
22	12984....	17337	12644....	17760	12310....	18190	11982....	18627	11660....	19073	8
23	12978....	17344	12638....	17767	12305....	18197	11976....	18635	11654....	19081	7
	12972....	17351	12633....	17774	12299....	18204	11971....	18642	11649....	19088	
	12967....	17358	12627....	17781	12293....	18211	11966....	18650	11644....	19096	
24	12961....	17365	12622....	17788	12288....	18219	11960....	18657	11638....	19103	6
25	12955....	17372	12616....	17795	12282....	18226	11955....	18664	11633....	19111	5
	12950....	17379	12610....	17802	12277....	18233	11949....	18672	11628....	19118	
	12944....	17386	12605....	17809	12271....	18240	11944....	18679	11622....	19126	
26	12938....	17393	12599....	17816	12266....	18248	11939....	18686	11617....	19133	4
27	12932....	17400	12593....	17824	12260....	18255	11933....	18694	11612....	19141	3
	12927....	17407	12588....	17831	12255....	18262	11928....	18701	11606....	19148	
	12921....	17414	12582....	17838	12249....	18269	11922....	18709	11601....	19156	
28	12915....	17421	12577....	17845	12244....	18277	11917....	18716	11596....	19163	2
29	12910....	17428	12571....	17852	12238....	18284	11912....	18723	11590....	19171	1
	12904....	17435	12566....	17859	12233....	18291	11906....	18731	11585....	19178	
	12898....	17442	12560....	17866	12227....	18298	11901....	18738	11580....	19186	
30	12893....	17449	12554....	17873	12222....	18306	11895....	18746	11575....	19193	0
	A	B	A	B	A	B	A	B	A	B	
	132°00'		131°30'		131°00'		130°30'		130°00'		

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE							
	50°00'		50°30'		51°00'		
	A	B	A	B	A	B	
0	11575.....19193		11259.....19649		10950.....20113	10646.....20585	30
1	11569.....19201		11254.....19657		10945.....20121	10640.....20593	29
	11564.....19208		11249.....19664		10939.....20128	10635.....20601	
	11559.....19216		11244.....19672		10934.....20136	10630.....20609	
2	11553.....19223		11239.....19680		10929.....20144	10625.....20617	28
3	11548.....19231		11233.....19687		10924.....20152	10620.....20625	27
	11543.....19238		11228.....19695		10919.....20160	10615.....20633	
	11537.....19246		11223.....19703		10914.....20167	10610.....20641	
4	11532.....19253		11218.....19710		10909.....20175	10605.....20649	26
5	11527.....19261		11213.....19718		10904.....20183	10600.....20657	25
	11522.....19269		11207.....19726		10899.....20191	10595.....20665	
	11516.....19276		11202.....19733		10894.....20199	10590.....20672	
6	11511.....19284		11197.....19741		10888.....20207	10585.....20680	24
7	11506.....19291		11192.....19749		10883.....20214	10580.....20688	23
	11501.....19299		11187.....19756		10878.....20222	10575.....20696	
	11495.....19306		11181.....19764		10873.....20230	10570.....20704	
8	11490.....19314		11176.....19772		10868.....20238	10565.....20712	22
9	11485.....19321		11171.....19779		10863.....20246	10560.....20720	21
	11479.....19329		11166.....19787		10858.....20254	10555.....20728	
	11474.....19337		11161.....19795		10853.....20261	10550.....20736	
10	11469.....19344		11156.....19803		10848.....20269	10545.....20744	20
11	11464.....19352		11150.....19810		10843.....20277	10540.....20752	19
	11458.....19359		11145.....19818		10838.....20285	10535.....20760	
	11453.....19367		11140.....19826		10832.....20293	10530.....20768	
12	11448.....19375		11135.....19834		10827.....20301	10525.....20776	18
13	11443.....19382		11130.....19841		10822.....20308	10520.....20784	17
	11437.....19390		11124.....19849		10817.....20316	10515.....20792	
	11432.....19397		11119.....19857		10812.....20324	10510.....20800	
14	11427.....19405		11114.....19864		10807.....20332	10505.....20808	16
15	11421.....19412		11109.....19872		10802.....20340	10500.....20816	15
	11416.....19420		11104.....19880		10797.....20348	10496.....20824	
	11411.....19428		11099.....19888		10792.....20356	10491.....20832	
16	11406.....19435		11094.....19895		10787.....20364	10486.....20840	14
17	11400.....19443		11088.....19903		10782.....20371	10481.....20848	13
	11395.....19450		11083.....19911		10777.....20379	10476.....20856	
	11390.....19458		11078.....19918		10772.....20387	10471.....20864	
18	11385.....19466		11073.....19926		10767.....20395	10466.....20872	12
19	11380.....19473		11068.....19934		10761.....20403	10461.....20880	11
	11374.....19481		11063.....19942		10756.....20411	10456.....20888	
	11369.....19488		11057.....19949		10751.....20419	10451.....20897	
20	11364.....19496		11052.....19957		10746.....20427	10446.....20905	10
21	11359.....19504		11047.....19965		10741.....20435	10441.....20913	9
	11353.....19511		11042.....19973		10736.....20442	10436.....20921	
	11348.....19519		11037.....19980		10731.....20450	10431.....20929	
22	11343.....19527		11032.....19988		10726.....20458	10426.....20937	8
23	11338.....19534		11027.....19996		10721.....20466	10421.....20945	7
	11332.....19542		11021.....20004		10716.....20474	10416.....20953	
	11327.....19549		11016.....20012		10711.....20482	10411.....20961	
24	11322.....19557		11011.....20019		10706.....20490	10406.....20969	6
25	11317.....19565		11006.....20027		10701.....20498	10401.....20977	5
	11311.....19572		11001.....20035		10696.....20506	10396.....20985	
	11306.....19580		10996.....20043		10691.....20514	10391.....20993	
26	11301.....19588		10991.....20050		10686.....20522	10386.....21001	4
27	11296.....19595		10986.....20058		10681.....20529	10381.....21009	3
	11291.....19603		10980.....20066		10676.....20537	10376.....21017	
	11285.....19611		10975.....20074		10671.....20545	10372.....21025	
28	11280.....19618		10970.....20082		10666.....20553	10367.....21033	2
29	11275.....19626		10965.....20089		10661.....20561	10362.....21042	1
	11270.....19634		10960.....20097		10656.....20569	10357.....21050	
	11265.....19641		10955.....20105		10651.....20577	10352.....21058	
30	11259.....19649		10950.....20113		10646.....20585	10347.....21066	0
	A	B	A	B	A	B	
	129°30'		129°00'		128°30'		127°30'

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	52°30'		53°00'		53°30'		54°00'		54°30'		
	A	B	A	B	A	B	A	B	A	B	
0	10053.....	21555	9765.....	22054	9482.....	22561	9204.....	23078	8931.....	23605	30
1	10049.....	21563	9760.....	22062	9477.....	22570	9200.....	23087	8927.....	23613	29
	10044.....	21572	9756.....	22070	9473.....	22578	9195.....	23095	8922.....	23622	
	10039.....	21580	9751.....	22079	9468.....	22587	9190.....	23104	8918.....	23631	
2	10034.....	21588	9746.....	22087	9463.....	22595	9186.....	23113	8913.....	23640	28
3	10029.....	21596	9741.....	22096	9459.....	22604	9181.....	23122	8909.....	23649	27
	10024.....	21605	9737.....	22104	9454.....	22612	9177.....	23130	8904.....	23658	
	10019.....	21613	9732.....	22112	9449.....	22621	9172.....	23139	8900.....	23667	
4	10015.....	21621	9727.....	22121	9445.....	22630	9168.....	23148	8895.....	23675	26
5	10010.....	21629	9722.....	22129	9440.....	22638	9163.....	23156	8891.....	23684	25
	10005.....	21638	9718.....	22138	9435.....	22647	9158.....	23165	8886.....	23693	
	10000.....	21646	9713.....	22146	9431.....	22655	9154.....	23174	8882.....	23702	
6	9995.....	21654	9708.....	22154	9426.....	22664	9149.....	23183	8877.....	23711	24
7	9990.....	21662	9703.....	22163	9421.....	22672	9145.....	23191	8873.....	23720	23
	9986.....	21671	9699.....	22171	9417.....	22681	9140.....	23200	8868.....	23729	
	9981.....	21679	9694.....	22180	9412.....	22690	9136.....	23209	8864.....	23738	
8	9976.....	21687	9689.....	22188	9407.....	22698	9131.....	23218	8859.....	23747	22
9	9971.....	21696	9684.....	22197	9403.....	22707	9126.....	23226	8855.....	23755	21
	9966.....	21704	9680.....	22205	9398.....	22715	9122.....	23235	8850.....	23764	
	9962.....	21712	9675.....	22213	9394.....	22724	9117.....	23244	8846.....	23773	
10	9957.....	21720	9670.....	22222	9389.....	22732	9113.....	23252	8842.....	23782	20
11	9952.....	21729	9665.....	22230	9384.....	22741	9108.....	23261	8837.....	23791	19
	9947.....	21737	9661.....	22239	9380.....	22750	9104.....	23270	8833.....	23800	
	9942.....	21745	9656.....	22247	9375.....	22758	9099.....	23279	8828.....	23809	
12	9937.....	21754	9651.....	22256	9370.....	22767	9094.....	23288	8824.....	23818	18
13	9933.....	21762	9647.....	22264	9366.....	22775	9090.....	23296	8819.....	23827	17
	9928.....	21770	9642.....	22272	9361.....	22784	9085.....	23305	8815.....	23836	
	9923.....	21778	9637.....	22281	9356.....	22793	9081.....	23314	8810.....	23845	
14	9918.....	21787	9632.....	22289	9352.....	22801	9076.....	23323	8806.....	23854	16
15	9913.....	21795	9628.....	22298	9347.....	22810	9072.....	23331	8801.....	23863	15
	9909.....	21803	9623.....	22306	9342.....	22818	9067.....	23340	8797.....	23871	
	9904.....	21812	9618.....	22315	9338.....	22827	9063.....	23349	8792.....	23880	
16	9899.....	21820	9614.....	22323	9333.....	22836	9058.....	23358	8788.....	23889	14
17	9894.....	21828	9609.....	22332	9329.....	22844	9054.....	23366	8783.....	23898	13
	9889.....	21837	9604.....	22340	9324.....	22853	9049.....	23375	8779.....	23907	
	9885.....	21845	9599.....	22349	9319.....	22862	9044.....	23384	8775.....	23916	
18	9880.....	21853	9595.....	22357	9315.....	22870	9040.....	23393	8770.....	23925	12
19	9875.....	21862	9590.....	22366	9310.....	22879	9035.....	23402	8766.....	23934	11
	9870.....	21870	9585.....	22374	9305.....	22887	9031.....	23410	8761.....	23943	
	9865.....	21878	9581.....	22382	9301.....	22896	9026.....	23419	8757.....	23952	
20	9861.....	21887	9576.....	22391	9296.....	22905	9022.....	23428	8752.....	23961	10
21	9856.....	21895	9571.....	22399	9292.....	22913	9017.....	23437	8748.....	23970	9
	9851.....	21903	9566.....	22408	9287.....	22922	9013.....	23446	8743.....	23979	
	9846.....	21912	9562.....	22416	9282.....	22931	9008.....	23454	8739.....	23988	
22	9841.....	21920	9557.....	22425	9278.....	22939	9004.....	23463	8734.....	23997	8
23	9837.....	21928	9552.....	22433	9273.....	22948	8999.....	23472	8730.....	24006	7
	9832.....	21937	9548.....	22442	9269.....	22957	8995.....	23481	8726.....	24015	
	9827.....	21945	9543.....	22450	9264.....	22965	8990.....	23490	8721.....	24024	
24	9822.....	21953	9538.....	22459	9259.....	22974	8985.....	23498	8717.....	24033	6
25	9818.....	21962	9534.....	22467	9255.....	22983	8981.....	23507	8712.....	24042	5
	9813.....	21970	9529.....	22476	9250.....	22991	8976.....	23516	8708.....	24051	
	9808.....	21978	9524.....	22484	9246.....	23000	8972.....	23525	8703.....	24060	
26	9803.....	21987	9520.....	22493	9241.....	23009	8967.....	23534	8699.....	24069	4
27	9798.....	21995	9515.....	22501	9236.....	23017	8963.....	23543	8694.....	24078	3
	9794.....	22003	9510.....	22510	9232.....	23026	8958.....	23551	8690.....	24087	
	9789.....	22012	9505.....	22519	9227.....	23035	8954.....	23560	8686.....	24096	
28	9784.....	22020	9501.....	22527	9223.....	23043	8949.....	23569	8681.....	24105	2
29	9779.....	22029	9496.....	22536	9218.....	23052	8945.....	23578	8677.....	24114	1
	9775.....	22037	9491.....	22544	9213.....	23061	8940.....	23587	8672.....	24123	
	9770.....	22045	9487.....	22553	9209.....	23069	8936.....	23596	8668.....	24132	
30	9765.....	22054	9482.....	22561	9204.....	23078	8931.....	23605	8663.....	24141	0
	A	B	A	B	A	B	A	B	A	B	
	127°00'		126°30'		126°00'		125°30'		125°00'		

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

	55°00'		55°30'		56°00'		56°30'		57°00'		
	A	B	A	B	A	B	A	B	A	B	
0	8663.....24141		8401.....24687		8143.....25244		7889.....25811		7641.....26389		30
1	8659.....24150		8396.....24696		8138.....25253		7885.....25821		7637.....26399		29
	8655.....24159		8392.....24706		8134.....25263		7881.....25830		7633.....26409		
	8650.....24168		8388.....24715		8130.....25272		7877.....25840		7629.....26418		
2	8646.....24177		8383.....24724		8125.....25281		7873.....25849		7624.....26428		28
3	8641.....24186		8379.....24733		8121.....25291		7868.....25859		7620.....26438		27
	8637.....24195		8375.....24742		8117.....25300		7864.....25868		7616.....26447		
	8633.....24204		8370.....24752		8113.....25309		7860.....25878		7612.....26457		
4	8628.....24213		8366.....24761		8108.....25319		7856.....25887		7608.....26467		26
5	8624.....24222		8362.....24770		8104.....25328		7852.....25897		7604.....26477		25
	8619.....24231		8357.....24779		8100.....25338		7848.....25907		7600.....26486		
	8615.....24240		8353.....24788		8096.....25347		7843.....25916		7596.....26496		
6	8611.....24249		8349.....24798		8092.....25356		7839.....25926		7592.....26506		24
7	8606.....24258		8344.....24807		8087.....25366		7835.....25935		7588.....26516		23
	8602.....24267		8340.....24816		8083.....25375		7831.....25945		7584.....26526		
	8597.....24276		8336.....24825		8079.....25385		7827.....25954		7579.....26535		
8	8593.....24286		8331.....24835		8075.....25394		7823.....25964		7575.....26545		22
9	8589.....24295		8327.....24844		8070.....25403		7818.....25974		7571.....26555		21
	8584.....24304		8323.....24853		8066.....25413		7814.....25983		7567.....26565		
	8580.....24313		8318.....24862		8062.....25422		7810.....25993		7563.....26574		
10	8575.....24322		8314.....24872		8058.....25432		7806.....26002		7559.....26584		20
11	8571.....24331		8310.....24881		8053.....25441		7802.....26012		7555.....26594		19
	8567.....24340		8305.....24890		8049.....25451		7798.....26022		7551.....26604		
	8562.....24349		8301.....24899		8045.....25460		7793.....26031		7547.....26614		
12	8558.....24358		8297.....24909		8041.....25469		7789.....26041		7543.....26623		18
13	8553.....24367		8292.....24918		8036.....25479		7785.....26051		7539.....26633		17
	8549.....24376		8288.....24927		8032.....25488		7781.....26060		7535.....26643		
	8545.....24385		8284.....24936		8028.....25498		7777.....26070		7531.....26653		
14	8540.....24395		8280.....24946		8024.....25507		7773.....26079		7526.....26663		16
15	8536.....24404		8275.....24955		8020.....25517		7769.....26089		7522.....26672		15
	8531.....24413		8271.....24964		8015.....25526		7764.....26099		7518.....26682		
	8527.....24422		8267.....24973		8011.....25536		7760.....26108		7514.....26692		
16	8523.....24431		8262.....24983		8007.....25545		7756.....26118		7510.....26702		14
17	8518.....24440		8258.....24992		8003.....25554		7752.....26128		7506.....26712		13
	8514.....24449		8254.....25001		7998.....25564		7748.....26137		7502.....26722		
	8510.....24458		8249.....25011		7994.....25573		7744.....26147		7498.....26731		
18	8505.....24467		8245.....25020		7990.....25583		7740.....26157		7494.....26741		12
19	8501.....24477		8241.....25029		7986.....25592		7736.....26166		7490.....26751		11
	8496.....24486		8237.....25038		7982.....25602		7731.....26176		7486.....26761		
	8492.....24495		8232.....25048		7977.....25611		7727.....26185		7482.....26771		
20	8488.....24504		8228.....25057		7973.....25621		7723.....26195		7478.....26781		10
21	8483.....24513		8224.....25066		7969.....25630		7719.....26205		7474.....26790		9
	8479.....24522		8219.....25076		7965.....25640		7715.....26214		7470.....26800		
	8475.....24531		8215.....25085		7961.....25649		7711.....26224		7466.....26810		
22	8470.....24540		8211.....25094		7956.....25659		7707.....26234		7462.....26820		8
23	8466.....24550		8207.....25104		7952.....25668		7702.....26244		7458.....26830		7
	8461.....24559		8202.....25113		7948.....25678		7698.....26253		7453.....26840		
	8457.....24568		8198.....25122		7944.....25687		7694.....26263		7449.....26850		
24	8453.....24577		8194.....25132		7940.....25697		7690.....26273		7445.....26860		6
25	8448.....24586		8189.....25141		7935.....25706		7686.....26282		7441.....26869		5
	8444.....24595		8185.....25150		7931.....25716		7682.....26292		7437.....26879		
	8440.....24605		8181.....25160		7927.....25725		7678.....26302		7433.....26889		
26	8435.....24614		8177.....25169		7923.....25735		7674.....26311		7429.....26899		4
27	8431.....24623		8172.....25178		7919.....25744		7670.....26321		7425.....26909		3
	8427.....24632		8168.....25188		7914.....25754		7665.....26331		7421.....26919		
	8422.....24641		8164.....25197		7910.....25763		7661.....26340		7417.....26929		
28	8418.....24650		8160.....25206		7906.....25773		7657.....26350		7413.....26939		2
29	8414.....24660		8155.....25216		7902.....25782		7653.....26360		7409.....26949		1
	8409.....24669		8151.....25225		7898.....25792		7649.....26370		7405.....26958		
	8405.....24678		8147.....25234		7893.....25801		7645.....26379		7401.....26968		
30	8401.....24687		8143.....25244		7889.....25811		7641.....26389		7397.....26978		0
	A	B	A	B	A	B	A	B	A	B	
	124°30'		124°00'		123°30'		123°00'		122°30'		

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	57°30'		58°00'		58°30'		59°00'		59°30'		
	A	B	A	B	A	B	A	B	A	B	
0	7397.....26978		7158.....27579		6923.....28191		6693.....28816		6468.....29453		30
1	7393.....26988		7154.....27589		6920.....28202		6690.....28827		6464.....29464		29
	7389.....26998		7150.....27599		6916.....28212		6686.....28837		6460.....29475		
	7385.....27008		7146.....27609		6912.....28222		6682.....28848		6457.....29485		
2	7381.....27018		7142.....27619		6908.....28233		6678.....28858		6453.....29496		28
3	7377.....27028		7138.....27630		6904.....28243		6674.....28869		6449.....29507		27
	7373.....27038		7134.....27640		6900.....28253		6671.....28879		6446.....29517		
	7369.....27048		7130.....27650		6896.....28264		6667.....28890		6442.....29528		
4	7365.....27058		7126.....27660		6892.....28274		6663.....28900		6438.....29539		26
5	7361.....27068		7122.....27670		6889.....28284		6659.....28911		6434.....29550		25
	7357.....27078		7118.....27680		6885.....28295		6655.....28921		6431.....29560		
	7353.....27088		7115.....27690		6881.....28305		6652.....28932		6427.....29571		
6	7349.....27098		7111.....27701		6877.....28315		6648.....28942		6423.....29582		24
7	7345.....27107		7107.....27711		6873.....28326		6644.....28953		6420.....29593		23
	7341.....27117		7103.....27721		6869.....28336		6640.....28964		6416.....29604		
	7337.....27127		7099.....27731		6865.....28346		6637.....28974		6412.....29614		
8	7333.....27137		7095.....27741		6862.....28357		6633.....28985		6409.....29625		22
9	7329.....27147		7091.....27751		6858.....28367		6629.....28995		6405.....29636		21
	7325.....27157		7087.....27761		6854.....28378		6625.....29006		6401.....29647		
	7321.....27167		7083.....27772		6850.....28388		6622.....29016		6397.....29657		
10	7317.....27177		7079.....27782		6846.....28398		6618.....29027		6394.....29668		20
11	7313.....27187		7075.....27792		6842.....28409		6614.....29038		6390.....29679		19
	7309.....27197		7071.....27802		6839.....28419		6610.....29048		6386.....29690		
	7305.....27207		7068.....27812		6835.....28429		6607.....29059		6383.....29701		
12	7301.....27217		7064.....27823		6831.....28440		6603.....29069		6379.....29711		18
13	7297.....27227		7060.....27833		6827.....28450		6599.....29080		6375.....29722		17
	7293.....27237		7056.....27843		6823.....28461		6595.....29091		6372.....29733		
	7289.....27247		7052.....27853		6819.....28471		6591.....29101		6368.....29744		
14	7285.....27257		7048.....27863		6815.....28481		6588.....29112		6364.....29755		16
15	7281.....27267		7044.....27874		6812.....28492		6584.....29122		6361.....29766		15
	7277.....27277		7040.....27884		6808.....28502		6580.....29133		6357.....29776		
	7273.....27287		7036.....27894		6804.....28513		6576.....29144		6353.....29787		
16	7269.....27297		7032.....27904		6800.....28523		6573.....29154		6349.....29798		14
17	7265.....27307		7028.....27914		6796.....28533		6569.....29165		6346.....29809		13
	7261.....27317		7024.....27925		6792.....28544		6565.....29175		6342.....29820		
	7257.....27327		7021.....27935		6789.....28554		6561.....29186		6338.....29831		
18	7253.....27337		7017.....27945		6785.....28565		6558.....29197		6335.....29841		12
19	7249.....27347		7013.....27955		6781.....28575		6554.....29207		6331.....29852		11
	7245.....27357		7009.....27965		6777.....28586		6550.....29218		6327.....29863		
	7241.....27367		7005.....27976		6773.....28596		6546.....29229		6324.....29874		
20	7237.....27377		7001.....27986		6770.....28607		6543.....29239		6320.....29885		10
21	7233.....27387		6997.....27996		6766.....28617		6539.....29250		6316.....29896		9
	7229.....27398		6993.....28006		6762.....28627		6535.....29261		6313.....29907		
	7225.....27408		6989.....28017		6758.....28638		6531.....29271		6309.....29917		
22	7221.....27418		6985.....28027		6754.....28648		6528.....29282		6305.....29929		8
23	7217.....27428		6982.....28037		6750.....28659		6524.....29293		6302.....29939		7
	7213.....27438		6978.....28047		6747.....28669		6520.....29303		6298.....29950		
	7209.....27448		6974.....28058		6743.....28680		6516.....29314		6294.....29961		
24	7205.....27458		6970.....28068		6739.....28690		6513.....29325		6291.....29972		6
25	7201.....27468		6966.....28078		6735.....28701		6509.....29335		6287.....29983		5
	7197.....27478		6962.....28089		6731.....28711		6505.....29346		6283.....29994		
	7193.....27488		6958.....28099		6728.....28722		6502.....29357		6280.....30005		
26	7190.....27498		6954.....28109		6724.....28732		6498.....29367		6276.....30015		4
27	7186.....27508		6951.....28119		6720.....28743		6494.....29378		6272.....30026		3
	7182.....27518		6947.....28130		6716.....28753		6490.....29389		6269.....30037		
	7178.....27528		6943.....28140		6712.....28763		6487.....29399		6265.....30048		
28	7174.....27539		6939.....28150		6709.....28774		6483.....29410		6261.....30059		2
29	7170.....27549		6935.....28161		6705.....28784		6479.....29421		6258.....30070		1
	7166.....27559		6931.....28171		6701.....28795		6475.....29432		6254.....30081		
	7162.....27569		6927.....28181		6697.....28806		6472.....29442		6251.....30092		
30	7158.....27579		6923.....28191		6693.....28816		6468.....29453		6247.....30103		0
	A	B	A	B	A	B	A	B	A	B	
	122°00'		121°30'		121°00'		120°30'		120°00'		

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

	60°00'		60°30'		61°00'		61°30'		62°00'		
	A	B	A	B	A	B	A	B	A	B	
0	6247.....30103		6030.....30766		5818.....31443		5610.....32134		5406.....32839		30
1	6243.....30114		6027.....30777		5815.....31454		5607.....32145		5403.....32851		29
	6240.....30125		6023.....30788		5811.....31466		5603.....32157		5400.....32863		
	6236.....30136		6020.....30800		5808.....31477		5600.....32169		5396.....32875		
2	6232.....30147		6016.....30811		5804.....31488		5596.....32180		5393.....32887		28
3	6229.....30158		6012.....30822		5801.....31500		5593.....32192		5390.....32898		27
	6225.....30169		6009.....30833		5797.....31511		5590.....32204		5386.....32910		
	6221.....30180		6005.....30844		5794.....31523		5586.....32215		5383.....32922		
4	6218.....30191		6002.....30856		5790.....31534		5583.....32227		5380.....32934		26
5	6214.....30202		5998.....30867		5787.....31546		5579.....32239		5376.....32946		25
	6210.....30213		5995.....30878		5783.....31557		5575.....32250		5373.....32958		
	6207.....30224		5991.....30889		5780.....31569		5572.....32262		5370.....32970		
6	6203.....30235		5987.....30900		5776.....31580		5569.....32274		5366.....32982		24
7	6200.....30245		5984.....30912		5773.....31591		5566.....32285		5363.....32994		23
	6196.....30256		5980.....30923		5769.....31603		5562.....32297		5360.....33006		
	6192.....30267		5977.....30934		5766.....31614		5559.....32309		5356.....33018		
8	6189.....30278		5973.....30945		5762.....31626		5555.....32320		5353.....33030		22
9	6185.....30289		5970.....30956		5759.....31637		5552.....32332		5350.....33042		21
	6181.....30300		5966.....30968		5755.....31649		5549.....32344		5346.....33054		
	6178.....30311		5963.....30979		5752.....31660		5545.....32355		5343.....33065		
10	6174.....30322		5959.....30990		5748.....31672		5542.....32367		5340.....33077		20
11	6171.....30334		5955.....31001		5745.....31683		5538.....32379		5336.....33089		19
	6167.....30345		5952.....31013		5741.....31694		5535.....32391		5333.....33101		
	6163.....30355		5948.....31024		5738.....31706		5532.....32402		5330.....33113		
12	6160.....30367		5945.....31035		5734.....31717		5528.....32414		5326.....33125		18
13	6156.....30378		5941.....31046		5731.....31729		5525.....32426		5323.....33137		17
	6152.....30389		5938.....31058		5727.....31740		5521.....32438		5320.....33149		
	6149.....30400		5934.....31069		5724.....31752		5518.....32449		5316.....33161		
14	6145.....30411		5931.....31080		5720.....31763		5515.....32461		5313.....33173		16
15	6142.....30422		5927.....31091		5717.....31775		5511.....32473		5310.....33185		15
	6138.....30433		5924.....31103		5714.....31786		5508.....32484		5306.....33197		
	6134.....30444		5920.....31114		5710.....31798		5504.....32496		5303.....33209		
16	6131.....30455		5917.....31125		5707.....31809		5501.....32508		5300.....33221		14
17	6127.....30466		5913.....31137		5703.....31821		5498.....32520		5296.....33233		13
	6124.....30477		5909.....31148		5700.....31833		5494.....32532		5293.....33245		
	6120.....30488		5906.....31159		5696.....31844		5491.....32543		5290.....33257		
18	6116.....30499		5902.....31170		5693.....31856		5487.....32555		5286.....33269		12
19	6113.....30510		5899.....31182		5689.....31867		5484.....32567		5283.....33281		11
	6109.....30521		5895.....31193		5686.....31879		5481.....32579		5280.....33293		
	6106.....30532		5892.....31204		5682.....31890		5477.....32590		5276.....33306		
20	6102.....30544		5888.....31216		5679.....31902		5474.....32602		5273.....33318		10
21	6098.....30555		5885.....31227		5675.....31913		5470.....32614		5270.....33330		9
	6095.....30566		5881.....31238		5672.....31925		5467.....32625		5266.....33342		
	6091.....30577		5878.....31250		5669.....31936		5464.....32638		5263.....33354		
22	6088.....30588		5874.....31261		5665.....31948		5460.....32649		5260.....33366		8
23	6084.....30599		5871.....31272		5662.....31960		5457.....32661		5257.....33378		7
	6080.....30610		5867.....31284		5658.....31971		5454.....32673		5253.....33390		
	6077.....30621		5864.....31295		5655.....31983		5450.....32685		5250.....33402		
24	6073.....30632		5860.....31306		5651.....31994		5447.....32697		5247.....33414		6
25	6070.....30643		5857.....31318		5648.....32006		5443.....32709		5243.....33426		5
	6066.....30655		5853.....31329		5644.....32018		5440.....32720		5240.....33438		
	6062.....30666		5850.....31340		5641.....32029		5437.....32732		5237.....33450		
26	6059.....30677		5846.....31352		5638.....32041		5433.....32744		5233.....33462		4
27	6055.....30688		5843.....31363		5634.....32052		5430.....32756		5230.....33475		3
	6052.....30699		5839.....31375		5631.....32064		5427.....32768		5227.....33487		
	6048.....30710		5836.....31386		5627.....32076		5423.....32780		5224.....33499		
28	6045.....30721		5832.....31397		5624.....32087		5420.....32792		5220.....33511		2
29	6041.....30733		5829.....31409		5620.....32099		5417.....32803		5217.....33523		1
	6037.....30744		5825.....31420		5617.....32110		5413.....32815		5214.....33535		
	6034.....30755		5822.....31431		5614.....32122		5410.....32827		5210.....33547		
30	6030.....30766		5818.....31443		5610.....32134		5406.....32839		5207.....33559		0
	A	B	A	B	A	B	A	B	A	B	
	119°30'		119°00'		118°30'		118°00'		117°30'		

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	62°30'		63°00'		63°30'		64°00'		64°30'		
	A	B	A	B	A	B	A	B	A	B	
0	5207.....33559		5012.....34295		4821.....35047		4634.....35816		4451.....36602		30
1	5204.....33572		5009.....34308		4818.....35060		4631.....35829		4448.....36615		29
	5200.....33584		5005.....34320		4815.....35073		4628.....35842		4445.....36628		
	5197.....33596		5002.....34332		4811.....35085		4625.....35855		4442.....36641		
2	5194.....33608		4999.....34345		4808.....35098		4622.....35868		4439.....36655		28
3	5191.....33620		4996.....34357		4805.....35111		4619.....35881		4436.....36668		27
	5187.....33632		4993.....34370		4802.....35123		4615.....35894		4433.....36681		
	5184.....33644		4989.....34382		4799.....35136		4612.....35907		4430.....36694		
4	5181.....33657		4986.....34395		4796.....35149		4609.....35920		4427.....36708		26
5	5178.....33669		4983.....34407		4793.....35161		4606.....35933		4424.....36721		25
	5174.....33681		4980.....34420		4789.....35174		4603.....35946		4421.....36734		
	5171.....33693		4977.....34432		4786.....35187		4600.....35959		4418.....36747		
6	5168.....33705		4973.....34444		4783.....35200		4597.....35972		4415.....36761		24
7	5164.....33717		4970.....34457		4780.....35212		4594.....35985		4412.....36774		23
	5161.....33730		4967.....34469		4777.....35225		4591.....35998		4409.....36787		
	5158.....33742		4964.....34482		4774.....35238		4588.....36011		4406.....36801		
8	5155.....33754		4961.....34494		4771.....35251		4585.....36024		4403.....36814		22
9	5152.....33766		4957.....34507		4767.....35263		4582.....36037		4400.....36827		21
	5148.....33779		4954.....34519		4764.....35276		4579.....36050		4397.....36841		
	5145.....33791		4951.....34532		4761.....35289		4576.....36063		4394.....36854		
10	5142.....33803		4948.....34544		4758.....35302		4573.....36076		4391.....36867		20
11	5138.....33815		4945.....34557		4755.....35314		4569.....36089		4388.....36881		19
	5135.....33827		4941.....34569		4752.....35327		4566.....36102		4385.....36894		
	5132.....33840		4938.....34582		4749.....35340		4563.....36115		4382.....36907		
12	5128.....33852		4935.....34594		4746.....35353		4560.....36128		4379.....36921		18
13	5125.....33864		4932.....34607		4742.....35365		4557.....36141		4376.....36934		17
	5122.....33876		4929.....34619		4739.....35378		4554.....36154		4373.....36948		
	5119.....33889		4925.....34632		4736.....35391		4551.....36167		4370.....36961		
14	5115.....33901		4922.....34644		4733.....35404		4548.....36180		4367.....36974		16
15	5112.....33913		4919.....34657		4730.....35417		4545.....36193		4364.....36988		15
	5109.....33925		4916.....34669		4727.....35429		4542.....36206		4361.....37001		
	5106.....33938		4913.....34682		4724.....35442		4539.....36220		4358.....37014		
16	5102.....33950		4910.....34694		4721.....35455		4536.....36233		4355.....37028		14
17	5099.....33962		4906.....34707		4718.....35468		4533.....36246		4352.....37041		13
	5096.....33974		4903.....34719		4714.....35481		4530.....36259		4349.....37055		
	5093.....33987		4900.....34732		4711.....35493		4527.....36272		4346.....37068		
18	5089.....33999		4897.....34744		4708.....35506		4524.....36285		4343.....37081		12
19	5086.....34011		4894.....34757		4705.....35519		4521.....36298		4340.....37095		11
	5083.....34024		4890.....34770		4702.....35532		4518.....36311		4337.....37108		
	5080.....34036		4887.....34782		4699.....35545		4515.....36325		4334.....37122		
20	5076.....34048		4884.....34795		4696.....35558		4512.....36338		4332.....37135		10
21	5073.....34061		4881.....34807		4693.....35571		4509.....36351		4329.....37149		9
	5070.....34073		4878.....34820		4690.....35583		4506.....36364		4326.....37162		
	5067.....34085		4875.....34832		4686.....35596		4503.....36377		4323.....37176		
22	5064.....34097		4871.....34845		4683.....35609		4500.....36390		4320.....37189		8
23	5060.....34110		4868.....34858		4680.....35622		4497.....36403		4317.....37203		7
	5057.....34122		4865.....34870		4677.....35635		4493.....36417		4314.....37216		
	5054.....34134		4862.....34883		4674.....35648		4490.....36430		4311.....37229		
24	5051.....34147		4859.....34896		4671.....35661		4487.....36443		4308.....37243		6
25	5047.....34159		4856.....34908		4668.....35674		4484.....36456		4305.....37256		5
	5044.....34172		4852.....34921		4665.....35686		4481.....36469		4302.....37270		
	5041.....34184		4849.....34933		4662.....35699		4478.....36483		4299.....37283		
26	5038.....34196		4846.....34946		4659.....35712		4475.....36496		4296.....37297		4
27	5034.....34209		4843.....34959		4656.....35725		4472.....36509		4293.....37310		3
	5031.....34221		4840.....34971		4652.....35738		4469.....36522		4290.....37324		
	5028.....34233		4837.....34984		4649.....35751		4466.....36535		4287.....37337		
28	5025.....34246		4833.....34997		4646.....35764		4463.....36549		4284.....37351		2
29	5022.....34258		4830.....35009		4643.....35777		4460.....36562		4281.....37365		1
	5018.....34270		4827.....35022		4640.....35790		4457.....36575		4278.....37378		
	5015.....34283		4824.....35035		4637.....35803		4454.....36588		4275.....37392		
30	5012.....34295		4821.....35047		4634.....35816		4451.....36602		4272.....37405		0
	A	B	A	B	A	B	A	B	A	B	
	117°00'		116°30'		116°00'		115°30'		115°00'		

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

	65°00'		65°30'		66°00'		66°30'		67°00'		
	A	B	A	B	A	B	A	B	A	B	
0	4272.....37405		4098.....38227		3927.....39069		3760.....39930		3597.....40812		30
1	4269.....37419		4095.....38241		3924.....39083		3757.....39945		3595.....40827		29
	4266.....37432		4092.....38255		3921.....39097		3755.....39959		3592.....40842		
	4264.....37446		4089.....38269		3918.....39111		3752.....39974		3589.....40857		
2	4261.....37459		4086.....38283		3916.....39125		3749.....39988		3587.....40872		28
3	4258.....37473		4083.....38297		3913.....39140		3746.....40003		3584.....40887		27
	4255.....37487		4080.....38311		3910.....39154		3744.....40017		3581.....40902		
	4252.....37500		4078.....38324		3907.....39168		3741.....40032		3579.....40916		
4	4249.....37514		4075.....38338		3904.....39182		3738.....40046		3576.....40931		26
5	4246.....37527		4072.....38352		3902.....39197		3735.....40061		3573.....40946		25
	4243.....37541		4069.....38366		3899.....39211		3733.....40076		3571.....40961		
	4240.....37554		4066.....38380		3896.....39225		3730.....40090		3568.....40976		
6	4237.....37568		4063.....38394		3893.....39239		3727.....40105		3565.....40991		24
7	4234.....37582		4060.....38408		3890.....39254		3725.....40119		3563.....41006		23
	4231.....37595		4057.....38422		3888.....39268		3722.....40134		3560.....41021		
	4228.....37609		3055.....38436		3885.....39282		3719.....40149		3557.....41036		
8	4225.....37623		4052.....38450		3882.....39296		3716.....40163		3555.....41051		22
9	4222.....37636		4049.....38464		3879.....39311		3714.....40178		3552.....41066		21
	4220.....37650		4046.....38478		3876.....39325		3711.....40192		3549.....41081		
	4217.....37663		4043.....38492		3874.....39339		3708.....40207		3547.....41096		
10	4214.....37677		4040.....38506		3871.....39353		3705.....40222		3544.....41111		20
11	4211.....37691		4037.....38520		3868.....39368		3703.....40236		3541.....41126		19
	4208.....37704		4035.....38533		3865.....39382		3700.....40251		3539.....41141		
	4205.....37718		4032.....38547		3863.....39396		3697.....40266		3536.....41156		
12	4202.....37732		4029.....38561		3860.....39411		3695.....40280		3533.....41171		18
13	4199.....37745		4026.....38575		3857.....39425		3692.....40295		3531.....41186		17
	4196.....37759		4023.....38589		3854.....39439		3689.....40310		3528.....41201		
	4193.....37773		4020.....38603		3851.....39454		3686.....40324		3525.....41216		
14	4190.....37786		4017.....38617		3849.....39468		3684.....40339		3523.....41231		16
15	4187.....37800		4015.....38631		3846.....39482		3681.....40354		3520.....41246		15
	4185.....37814		4012.....38645		3843.....39497		3678.....40368		3517.....41261		
	4182.....37828		4009.....38660		3840.....39511		3676.....40383		3515.....41276		
16	4179.....37841		4006.....38674		3838.....39525		3673.....40398		3512.....41291		14
17	4176.....37855		4003.....38688		3835.....39540		3670.....40413		3509.....41307		13
	4173.....37869		4000.....38702		3832.....39554		3667.....40427		3507.....41322		
	4170.....37882		3998.....38716		3829.....39569		3665.....40442		3504.....41337		
18	4167.....37896		3995.....38730		3826.....39583		3662.....40457		3502.....41352		12
19	4164.....37910		3992.....38744		3824.....39597		3659.....40471		3499.....41367		11
	4161.....37924		3989.....38758		3821.....39612		3657.....40486		3496.....41382		
	4158.....37937		3986.....38772		3818.....39626		3654.....40501		3494.....41397		
20	4155.....37951		3983.....38786		3815.....39641		3651.....40516		3491.....41412		10
21	4153.....37965		3981.....38800		3813.....39655		3648.....40530		3488.....41427		9
	4150.....37979		3978.....38814		3810.....39669		3646.....40545		3486.....41443		
	4147.....37992		3975.....38828		3807.....39684		3643.....40560		3483.....41458		
22	4144.....38006		3972.....38842		3804.....39698		3640.....40575		3480.....41473		8
23	4141.....38020		3969.....38856		3801.....39713		3638.....40590		3478.....41488		7
	4138.....38034		3966.....38871		3799.....39727		3635.....40604		3475.....41503		
	4135.....38048		3964.....38885		3796.....39742		3632.....40619		3473.....41518		
24	4132.....38061		3961.....38899		3793.....39756		3630.....40634		3470.....41533		6
25	4129.....38075		3958.....38913		3790.....39771		3627.....40649		3467.....41549		5
	4127.....38089		3955.....38927		3788.....39785		3624.....40664		3465.....41564		
	4124.....38103		3952.....38941		3785.....39799		3622.....40678		3462.....41579		
26	4121.....38117		3949.....38955		3782.....39814		3619.....40693		3459.....41594		4
27	4118.....38130		3947.....38969		3779.....39828		3616.....40708		3457.....41609		3
	4115.....38144		3944.....38984		3777.....39843		3613.....40723		3454.....41625		
	4112.....38158		3941.....38998		3774.....39857		3611.....40738		3452.....41640		
28	4109.....38172		3938.....39012		3771.....39872		3608.....40753		3449.....41655		2
29	4106.....38186		3935.....39026		3768.....39886		3605.....40768		3446.....41670		1
	4103.....38200		3933.....39040		3766.....39901		3603.....40782		3444.....41685		
	4101.....38213		3930.....39054		3763.....39915		3600.....40797		3441.....41701		
30	4098.....38227		3927.....39069		3760.....39930		3597.....40812		3438.....41716		0
	A	B	A	B	A	B	A	B	A	B	
	114°30'		114°00'		113°30'		113°00'		112°30'		

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	67°30'		68°00'		68°30'		69°00'		69°30'		
	A	B	A	B	A	B	A	B	A	B	
0	3438.....41716		3283.....42642		3132.....43592		2985.....44567		2841.....45567		30
1	3436.....41731		3281.....42658		3130.....43608		2982.....44583		2839.....45584		29
	3433.....41746		3278.....42674		3127.....43624		2980.....44600		2836.....45601		
	3431.....41762		3276.....42689		3125.....43641		2978.....44616		2834.....45618		
2	3428.....41777		3273.....42705		3122.....43657		2975.....44633		2832.....45635		28
3	3425.....41792		3271.....42721		3120.....43673		2973.....44649		2829.....45652		27
	3423.....41808		3268.....42736		3117.....43689		2970.....44666		2827.....45669		
	3420.....41823		3266.....42752		3115.....43705		2968.....44682		2825.....45686		
4	3418.....41838		3263.....42768		3112.....43721		2965.....44699		2822.....45703		26
5	3415.....41853		3260.....42783		3110.....43737		2963.....44715		2820.....45720		25
	3412.....41869		3258.....42799		3107.....43753		2961.....44732		2818.....45737		
	3410.....41884		3255.....42815		3105.....43769		2958.....44748		2815.....45754		
6	3407.....41899		3253.....42830		3102.....43785		2956.....44765		2813.....45771		24
7	3404.....41915		3250.....42846		3100.....43801		2953.....44782		2811.....45788		23
	3402.....41930		3248.....42862		3097.....43818		2951.....44798		2808.....45805		
	3399.....41945		3245.....42878		3095.....43834		2949.....44815		2806.....45822		
8	3397.....41961		3243.....42893		3092.....43850		2946.....44831		2804.....45839		22
9	3394.....41976		3240.....42909		3090.....43866		2944.....44848		2801.....45856		21
	3391.....41991		3237.....42925		3088.....43882		2941.....44864		2799.....45873		
	3389.....42007		3235.....42941		3085.....43898		2939.....44881		2797.....45890		
10	3386.....42022		3233.....42956		3083.....43914		2936.....44898		2794.....45907		20
11	3384.....42038		3230.....42972		3080.....43931		2934.....44914		2792.....45924		19
	3381.....42053		3227.....42988		3078.....43947		2932.....44931		2789.....45941		
	3379.....42068		3225.....43004		3075.....43963		2929.....44947		2787.....45958		
12	3376.....42084		3222.....43020		3073.....43979		2927.....44964		2785.....45975		18
13	3373.....42099		3220.....43035		3070.....43995		2924.....44981		2782.....45992		17
	3371.....42115		3217.....43051		3068.....44012		2922.....44997		2780.....46009		
	3368.....42130		3215.....43067		3065.....44028		2920.....45014		2778.....46026		
14	3366.....42145		3212.....43083		3063.....44044		2917.....45031		2775.....46043		16
15	3363.....42161		3210.....43099		3060.....44060		2915.....45047		2773.....46061		15
	3360.....42176		3207.....43114		3058.....44077		2913.....45064		2771.....46078		
	3358.....42192		3205.....43130		3056.....44093		2910.....45081		2768.....46095		
16	3355.....42207		3202.....43146		3053.....44109		2908.....45097		2766.....46112		14
17	3353.....42223		3200.....43162		3051.....44125		2905.....45114		2764.....46129		13
	3350.....42238		3197.....43178		3048.....44142		2903.....45131		2761.....46146		
	3348.....42254		3195.....43194		3046.....44158		2901.....45147		2759.....46163		
18	3345.....42269		3192.....43210		3043.....44174		2898.....45164		2757.....46181		12
19	3342.....42285		3190.....43225		3041.....44190		2896.....45181		2755.....46198		11
	3340.....42300		3187.....43241		3038.....44207		2893.....45198		2752.....46215		
	3337.....42316		3185.....43257		3036.....44223		2891.....45214		2750.....46232		
20	3335.....42331		3182.....43273		3033.....44239		2889.....45231		2748.....46249		10
21	3332.....42347		3180.....43289		3031.....44256		2886.....45248		2745.....46266		9
	3329.....42362		3177.....43305		3029.....44272		2884.....45265		2743.....46284		
	3327.....42378		3175.....43321		3026.....44288		2881.....45281		2741.....46301		
22	3324.....42393		3172.....43337		3024.....44305		2879.....45298		2738.....46318		8
23	3322.....42409		3170.....43353		3021.....44321		2877.....45315		2736.....46335		7
	3319.....42424		3167.....43369		3019.....44337		2874.....45332		2734.....46353		
	3317.....42440		3165.....43385		3016.....44354		2872.....45348		2731.....46370		
24	3314.....42455		3162.....43400		3014.....44370		2870.....45365		2729.....46387		6
25	3312.....42471		3160.....43416		3012.....44386		2867.....45382		2727.....46404		5
	3309.....42486		3157.....43432		3009.....44403		2865.....45399		2724.....46422		
	3306.....42502		3155.....43448		3007.....44419		2862.....45416		2722.....46439		
26	3304.....42518		3152.....43464		3004.....44436		2860.....45433		2720.....46456		4
27	3301.....42533		3150.....43480		3002.....44452		2858.....45449		2717.....46473		3
	3299.....42549		3147.....43496		2999.....44468		2855.....45466		2715.....46491		
	3296.....42564		3145.....43512		2997.....44485		2853.....45483		2713.....46508		
28	3294.....42580		3142.....43528		2994.....44501		2851.....45500		2711.....46525		2
29	3291.....42596		3140.....43544		2992.....44518		2848.....45517		2708.....46543		1
	3289.....42611		3137.....43560		2990.....44534		2846.....45534		2706.....46560		
	3286.....42627		3135.....43576		2987.....44551		2844.....45551		2704.....46577		
30	3283.....42642		3132.....43592		2985.....44567		2841.....45567		2701.....46595		0
	A	B	A	B	A	B	A	B	A	B	
	112°00'		111°30'		111°00'		110°30'		110°00'		

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

	70°00'		70°30'		71°00'		71°30'		72°00'		
	A	B	A	B	A	B	A	B	A	B	
0	2701.....46595		2565.....47650		2433.....48736		2304.....49852		2179.....51002		30
1	2699.....46612		2563.....47668		2431.....48754		2302.....49871		2177.....51021		29
	2697.....46630		2561.....47686		2429.....48772		2300.....49890		2175.....51041		
	2694.....46647		2559.....47704		2427.....48791		2298.....49909		2173.....51060		
2	2692.....46664		2556.....47722		2424.....48809		2296.....49928		2171.....51080		28
3	2690.....46682		2554.....47740		2422.....48828		2294.....49947		2169.....51099		27
	2688.....46699		2552.....47758		2420.....48846		2292.....49966		2167.....51119		
	2685.....46716		2550.....47775		2418.....48864		2290.....49985		2165.....51138		
4	2683.....46734		2547.....47793		2416.....48883		2287.....50004		2163.....51158		26
5	2681.....46751		2545.....47811		2413.....48901		2285.....50023		2161.....51177		25
	2678.....46769		2543.....47829		2411.....48920		2283.....50042		2159.....51197		
	2676.....46786		2541.....47847		2409.....48938		2281.....50061		2157.....51216		
6	2674.....46804		2539.....47865		2407.....48957		2279.....50080		2155.....51236		24
7	2672.....46821		2536.....47883		2405.....48975		2277.....50098		2153.....51255		23
	2669.....46839		2534.....47901		2403.....48993		2275.....50117		2151.....51275		
	2667.....46856		2532.....47919		2400.....49012		2273.....50137		2149.....51294		
8	2665.....46873		2530.....47937		2398.....49030		2271.....50156		2147.....51314		22
9	2662.....46891		2528.....47955		2396.....49049		2269.....50175		2145.....51334		21
	2660.....46908		2525.....47973		2394.....49067		2266.....50194		2143.....51353		
	2658.....46926		2523.....47991		2392.....49086		2264.....50213		2141.....51373		
10	2656.....46943		2521.....48009		2390.....49104		2262.....50232		2138.....51392		20
11	2653.....46961		2519.....48027		2387.....49123		2260.....50251		2136.....51412		19
	2651.....46978		2516.....48045		2385.....49141		2258.....50270		2134.....51432		
	2649.....46996		2514.....48063		2383.....49160		2256.....50289		2132.....51451		
12	2646.....47014		2512.....48081		2381.....49179		2254.....50308		2130.....51471		18
13	2644.....47031		2510.....48099		2379.....49197		2252.....50327		2128.....51491		17
	2642.....47049		2507.....48117		2377.....49216		2250.....50346		2126.....51510		
	2640.....47066		2505.....48135		2375.....49234		2248.....50365		2124.....51530		
14	2637.....47084		2503.....48153		2372.....49253		2246.....50385		2122.....51550		16
15	2635.....47101		2501.....48171		2370.....49271		2243.....50404		2120.....51570		15
	2633.....47119		2499.....48189		2368.....49290		2241.....50423		2118.....51589		
	2631.....47137		2496.....48207		2366.....49309		2239.....50442		2116.....51609		
16	2628.....47154		2494.....48226		2364.....49327		2237.....50461		2114.....51629		14
17	2626.....47172		2492.....48244		2362.....49346		2235.....50480		2112.....51649		13
	2624.....47189		2490.....48262		2360.....49365		2233.....50499		2110.....51668		
	2622.....47207		2488.....48280		2358.....49383		2231.....50519		2108.....51688		
18	2619.....47225		2485.....48298		2355.....49402		2229.....50538		2106.....51708		12
19	2617.....47242		2483.....48316		2353.....49421		2227.....50557		2104.....51728		11
	2615.....47269		2481.....48334		2351.....49439		2225.....50576		2102.....51747		
	2613.....47278		2479.....48352		2349.....49458		2223.....50596		2100.....51767		
20	2610.....47295		2477.....48371		2347.....49477		2221.....50615		2098.....51787		10
21	2608.....47313		2474.....48389		2345.....49495		2218.....50634		2096.....51807		9
	2606.....47331		2472.....48407		2343.....49514		2216.....50653		2094.....51827		
	2604.....47348		2470.....48425		2340.....49533		2214.....50673		2092.....51847		
22	2601.....47366		2468.....48443		2338.....49551		2212.....50692		2090.....51867		8
23	2599.....47384		2466.....48462		2336.....49570		2210.....50711		2088.....51886		7
	2597.....47402		2463.....48480		2334.....49589		2208.....50730		2086.....51906		
	2594.....47419		2461.....48498		2332.....49608		2206.....50750		2084.....51926		
24	2592.....47437		2459.....48516		2330.....49626		2204.....50769		2082.....51946		6
25	2590.....47455		2457.....48534		2328.....49645		2202.....50788		2080.....51966		5
	2588.....47472		2455.....48553		2325.....49664		2200.....50808		2078.....51986		
	2585.....47490		2453.....48571		2323.....49683		2198.....50827		2076.....52006		
26	2583.....47508		2450.....48589		2321.....49702		2196.....50846		2074.....52026		4
27	2581.....47526		2448.....48608		2319.....49720		2194.....50866		2072.....52046		3
	2579.....47544		2446.....48626		2317.....49739		2192.....50885		2070.....52066		
	2576.....47561		2444.....48644		2315.....49758		2190.....50905		2068.....52086		
28	2574.....47579		2442.....48662		2313.....49777		2188.....50924		2066.....52106		2
29	2572.....47597		2439.....48681		2311.....49796		2185.....50943		2064.....52126		1
	2570.....47615		2437.....48699		2309.....49815		2183.....50963		2062.....52146		
	2568.....47633		2435.....48717		2306.....49833		2181.....50982		2060.....52166		
30	2565.....47650		2433.....48736		2304.....49852		2179.....51002		2058.....52186		0
	A	B	A	B	A	B	A	B	A	B	
	109°30'		109°00'		108°30'		108°00'		107°30'		

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	72°30'		73°00'		73°30'		74°00'		74°30'		
	A	B	A	B	A	B	A	B	A	B	
0	2058.....	52186	1940.....	53406	1826.....	54666	1716.....	55966	1609.....	57310	30
1	2056.....	52206	1938.....	53427	1824.....	54687	1714.....	55988	1607.....	57333	29
	2054.....	52226	1936.....	53448	1823.....	54708	1712.....	56010	1605.....	57356	
	2052.....	52246	1935.....	53468	1821.....	54730	1710.....	56032	1604.....	57378	
2	2050.....	52266	1933.....	53489	1819.....	54751	1709.....	56054	1602.....	57401	28
3	2048.....	52286	1931.....	53510	1817.....	54773	1707.....	56076	1600.....	57424	27
	2046.....	52306	1929.....	53531	1815.....	54794	1705.....	56099	1598.....	57447	
	2044.....	52326	1927.....	53551	1813.....	54815	1703.....	56121	1597.....	57470	
4	2042.....	52346	1925.....	53572	1811.....	54837	1701.....	56143	1595.....	57493	26
5	2040.....	52366	1923.....	53593	1809.....	54858	1700.....	56165	1593.....	57516	25
	2038.....	52387	1921.....	53614	1808.....	54880	1698.....	56187	1591.....	57538	
	2036.....	52407	1919.....	53634	1806.....	54901	1696.....	56209	1590.....	57561	
6	2034.....	52427	1917.....	53655	1804.....	54922	1694.....	56231	1588.....	57584	24
7	2032.....	52447	1915.....	53676	1802.....	54944	1692.....	56254	1586.....	57607	23
	2030.....	52467	1913.....	53697	1800.....	54965	1691.....	56276	1584.....	57630	
	2028.....	52487	1911.....	53718	1798.....	54987	1689.....	56298	1583.....	57653	
8	2026.....	52508	1910.....	53738	1796.....	55008	1687.....	56320	1581.....	57676	22
9	2024.....	52528	1908.....	53759	1795.....	55030	1685.....	56342	1579.....	57699	21
	2022.....	52548	1906.....	53780	1793.....	55051	1683.....	56365	1578.....	57722	
	2020.....	52568	1904.....	53801	1791.....	55073	1682.....	56387	1576.....	57745	
10	2018.....	52588	1902.....	53822	1789.....	55095	1680.....	56409	1574.....	57768	20
11	2016.....	52609	1900.....	53843	1787.....	55116	1678.....	56431	1572.....	57791	19
	2014.....	52629	1898.....	53864	1785.....	55138	1676.....	56454	1571.....	57814	
	2012.....	52649	1896.....	53884	1783.....	55159	1674.....	56476	1569.....	57837	
12	2010.....	52670	1894.....	53905	1782.....	55181	1673.....	56498	1567.....	57860	18
13	2009.....	52690	1892.....	53926	1780.....	55202	1671.....	56521	1565.....	57884	17
	2007.....	52710	1890.....	53947	1778.....	55224	1669.....	56543	1564.....	57907	
	2005.....	52730	1889.....	53968	1776.....	55246	1667.....	56565	1562.....	57930	
14	2003.....	52751	1887.....	53989	1774.....	55267	1665.....	56588	1560.....	57953	16
15	2001.....	52771	1885.....	54010	1772.....	55289	1664.....	56610	1559.....	57976	15
	1999.....	52791	1883.....	54031	1771.....	55311	1662.....	56632	1557.....	57999	
	1997.....	52812	1881.....	54052	1769.....	55332	1660.....	56655	1555.....	58022	
16	1995.....	52832	1879.....	54073	1767.....	55354	1658.....	56677	1553.....	58046	14
17	1993.....	52852	1877.....	54094	1765.....	55376	1657.....	56700	1552.....	58069	13
	1991.....	52873	1875.....	54115	1763.....	55397	1655.....	56722	1550.....	58092	
	1989.....	52893	1873.....	54136	1761.....	55419	1653.....	56745	1548.....	58115	
18	1987.....	52914	1871.....	54157	1760.....	55441	1651.....	56767	1546.....	58138	12
19	1985.....	52934	1870.....	54178	1758.....	55463	1650.....	56790	1545.....	58162	11
	1983.....	52954	1868.....	54199	1756.....	55484	1648.....	56812	1543.....	58185	
	1981.....	52975	1866.....	54220	1754.....	55506	1646.....	56835	1541.....	58208	
20	1979.....	52995	1864.....	54242	1752.....	55528	1644.....	56857	1540.....	58232	10
21	1977.....	53016	1862.....	54263	1750.....	55550	1642.....	56880	1538.....	58255	9
	1975.....	53036	1860.....	54284	1749.....	55572	1641.....	56902	1536.....	58278	
	1973.....	53057	1858.....	54305	1747.....	55593	1639.....	56925	1534.....	58302	
22	1971.....	53077	1856.....	54326	1745.....	55615	1637.....	56947	1533.....	58325	8
23	1969.....	53098	1854.....	54347	1743.....	55637	1635.....	56970	1531.....	58348	7
	1967.....	53118	1853.....	54368	1741.....	55659	1634.....	56992	1529.....	58372	
	1966.....	53139	1851.....	54390	1739.....	55681	1632.....	57015	1528.....	58395	
24	1964.....	53159	1849.....	54411	1738.....	55703	1630.....	57038	1526.....	58418	6
25	1962.....	53180	1847.....	54432	1736.....	55725	1628.....	57060	1524.....	58442	5
	1960.....	53200	1845.....	54453	1734.....	55746	1627.....	57083	1523.....	58465	
	1958.....	53221	1843.....	54474	1732.....	55768	1625.....	57106	1521.....	58489	
26	1956.....	53241	1841.....	54496	1730.....	55790	1623.....	57128	1519.....	58512	4
27	1954.....	53262	1839.....	54517	1728.....	55812	1621.....	57151	1517.....	58536	3
	1952.....	53283	1837.....	54538	1727.....	55834	1619.....	57174	1516.....	58559	
	1950.....	53303	1836.....	54559	1725.....	55856	1618.....	57196	1514.....	58583	
28	1948.....	53324	1834.....	54581	1723.....	55878	1616.....	57219	1512.....	58606	2
29	1946.....	53344	1832.....	54602	1721.....	55900	1614.....	57242	1511.....	58630	1
	1944.....	53365	1830.....	54623	1719.....	55922	1612.....	57265	1509.....	58653	
	1942.....	53386	1828.....	54644	1718.....	55944	1611.....	57287	1507.....	58677	
30	1940.....	53406	1826.....	54666	1716.....	55966	1609.....	57310	1506.....	58700	0
	A	B	A	B	A	B	A	B	A	B	
	107°00'		106°30'		106°00'		105°30'		105°00'		

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

	75°00'		75°30'		76°00'		76°30'		77°00'		
	A	B	A	B	A	B	A	B	A	B	
0	1506.....58700		1406.....60140		1310.....61632		1217.....63181		1128.....64791		30
1	1504.....58724		1404.....60164		1308.....61658		1215.....63208		1126.....64819		29
	1502.....58748		1403.....60189		1306.....61683		1214.....63234		1125.....64846		
	1500.....58771		1401.....60213		1305.....61709		1212.....63260		1123.....64873		
2	1499.....58795		1399.....60238		1303.....61734		1211.....63287		1122.....64901		28
3	1497.....58818		1398.....60262		1301.....61759		1209.....63313		1120.....64928		27
	1495.....58842		1396.....60287		1300.....61785		1208.....63340		1119.....64956		
	1494.....58866		1394.....60311		1299.....61810		1206.....63366		1117.....64983		
4	1492.....58889		1393.....60336		1297.....61836		1205.....63392		1116.....65011		26
5	1490.....58913		1391.....60360		1295.....61861		1203.....63419		1114.....65038		25
	1489.....58937		1390.....60385		1294.....61887		1202.....63445		1113.....65066		
	1487.....58960		1388.....60410		1292.....61912		1200.....63472		1112.....65093		
6	1485.....58984		1386.....60434		1291.....61938		1199.....63498		1110.....65121		24
7	1484.....59008		1385.....60459		1289.....61963		1197.....63525		1109.....65148		23
	1482.....59032		1383.....60483		1288.....61989		1196.....63551		1107.....65176		
	1480.....59055		1381.....60508		1286.....62014		1194.....63578		1106.....65204		
8	1479.....59079		1380.....60533		1284.....62040		1193.....63605		1104.....65231		22
9	1477.....59103		1378.....60557		1283.....62065		1191.....63631		1103.....65259		21
	1475.....59127		1377.....60582		1281.....62091		1190.....63658		1101.....65287		
	1474.....59151		1375.....60607		1280.....62117		1188.....63684		1100.....65314		
10	1472.....59175		1373.....60631		1278.....62142		1187.....63711		1099.....65342		20
11	1470.....59198		1372.....60656		1277.....62168		1185.....63738		1097.....65370		19
	1469.....59222		1370.....60681		1275.....62194		1184.....63764		1096.....65398		
	1467.....59246		1368.....60706		1274.....62219		1182.....63791		1094.....65425		
12	1465.....59270		1367.....60730		1272.....62245		1181.....63818		1093.....65453		18
13	1464.....59294		1365.....60755		1270.....62271		1179.....63845		1091.....65481		17
	1462.....59318		1364.....60780		1269.....62296		1178.....63871		1090.....65509		
	1460.....59342		1362.....60805		1267.....62322		1176.....63898		1089.....65537		
14	1459.....59366		1360.....60830		1266.....62348		1175.....63925		1087.....65564		16
15	1457.....59390		1359.....60855		1264.....62374		1173.....63952		1086.....65592		15
	1455.....59414		1357.....60879		1263.....62400		1172.....63978		1084.....65620		
	1454.....59438		1356.....60904		1261.....62425		1170.....64005		1083.....65648		
16	1452.....59462		1354.....60929		1260.....62451		1169.....64032		1081.....65676		14
17	1450.....59486		1352.....60954		1258.....62477		1167.....64059		1080.....65704		13
	1449.....59510		1351.....60979		1257.....62503		1166.....64086		1079.....65732		
	1447.....59534		1349.....61004		1255.....62529		1164.....64113		1077.....65760		
18	1445.....59558		1348.....61029		1253.....62555		1163.....64140		1076.....65788		12
19	1444.....59582		1346.....61054		1252.....62581		1161.....64167		1074.....65816		11
	1442.....59606		1344.....61079		1250.....62607		1160.....64194		1073.....65844		
	1440.....59630		1343.....61104		1249.....62633		1158.....64221		1071.....65872		
20	1439.....59654		1341.....61129		1247.....62659		1157.....64248		1070.....65900		10
21	1437.....59678		1340.....61154		1246.....62685		1155.....64275		1069.....65928		9
	1435.....59703		1338.....61179		1244.....62711		1154.....64302		1067.....65957		
	1434.....59727		1336.....61204		1243.....62737		1152.....64329		1066.....65985		
22	1432.....59751		1335.....61229		1241.....62763		1151.....64356		1064.....66013		8
23	1430.....59775		1333.....61254		1240.....62789		1150.....64383		1063.....66041		7
	1429.....59800		1332.....61279		1238.....62815		1148.....64410		1061.....66069		
	1427.....59824		1330.....61304		1237.....62841		1147.....64437		1060.....66098		
24	1425.....59848		1329.....61330		1235.....62867		1145.....64464		1059.....66126		6
25	1424.....59872		1327.....61355		1234.....62893		1144.....64491		1057.....66154		5
	1422.....59896		1325.....61380		1232.....62919		1142.....64518		1056.....66182		
	1421.....59921		1324.....61405		1230.....62945		1141.....64546		1054.....66211		
26	1419.....59945		1322.....61430		1229.....62971		1139.....64573		1053.....66239		4
27	1417.....59969		1321.....61456		1227.....62998		1138.....64600		1052.....66267		3
	1416.....59994		1319.....61481		1226.....63024		1136.....64627		1050.....66296		
	1414.....60018		1317.....61506		1224.....63050		1135.....64655		1049.....66324		
28	1412.....60042		1316.....61531		1223.....63076		1133.....64682		1047.....66352		2
29	1411.....60067		1314.....61556		1221.....63103		1132.....64709		1046.....66381		1
	1409.....60091		1313.....61582		1220.....63129		1130.....64736		1045.....66409		
	1407.....60116		1311.....61607		1218.....63155		1129.....64764		1043.....66438		
30	1406.....60140		1310.....61632		1217.....63181		1128.....64791		1042.....66466		0
	A	B	A	B	A	B	A	B	A	B	
	104°30'		104°00'		103°30'		103°00'		102°30'		

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	77°30'		78°00'		78°30'		79°00'		79°30'		
	A	B	A	B	A	B	A	B	A	B	
0	1042.....66466		960.....68212		881.....70034		805.....71940		733.....73837		30
1	1040.....66495		958.....68242		879.....70065		804.....71973		732.....73971		29
	1039.....66523		957.....68272		878.....70097		803.....72005		731.....74005		
	1038.....66552		955.....68301		877.....70128		802.....72038		730.....74039		
2	1036.....65580		954.....68331		876.....70159		800.....72070		729.....74073		28
3	1035.....66609		953.....68361		874.....70190		799.....72103		728.....74107		27
	1033.....66638		951.....68391		873.....70221		798.....72136		726.....74142		
	1032.....66666		950.....68421		872.....70252		797.....72168		725.....74176		
4	1031.....66695		949.....68450		870.....70284		796.....72201		724.....74210		26
5	1029.....66724		947.....68480		869.....70315		794.....72234		723.....74245		25
	1028.....66752		946.....68510		868.....70346		793.....72266		722.....74279		
	1026.....66781		945.....68540		867.....70377		792.....72299		721.....74313		
6	1025.....66810		943.....68570		865.....70409		791.....72332		719.....74348		24
7	1024.....66838		942.....68600		864.....70440		790.....72365		718.....74382		23
	1022.....66867		941.....68630		863.....70471		788.....72397		717.....74417		
	1021.....66896		939.....68660		862.....70503		787.....72430		716.....74451		
8	1020.....66925		938.....68690		860.....70534		786.....72463		715.....74486		22
9	1018.....66953		937.....68720		859.....70566		785.....72496		714.....74520		21
	1017.....66982		935.....68750		858.....70597		783.....72529		712.....74555		
	1015.....67011		934.....68781		856.....70629		782.....72562		711.....74589		
10	1014.....67040		933.....68811		855.....70660		781.....72595		710.....74624		20
11	1013.....67069		932.....68841		854.....70692		780.....72628		709.....74659		19
	1011.....67098		930.....68871		853.....70723		779.....72661		708.....74693		
	1010.....67127		929.....68901		851.....70755		777.....72694		707.....74728		
12	1008.....67156		928.....68931		850.....70786		776.....72727		706.....74763		18
13	1007.....67185		926.....68962		849.....70818		775.....72760		704.....74797		17
	1006.....67214		925.....68992		848.....70850		774.....72794		703.....74832		
	1004.....67243		924.....69022		846.....70881		772.....72827		702.....74867		
14	1003.....67272		922.....69053		845.....70913		771.....72860		701.....74902		16
15	1002.....67301		921.....69083		844.....70945		770.....72893		700.....74937		15
	1000.....67330		920.....69113		843.....70976		769.....72926		699.....74972		
	999.....67359		918.....69144		841.....71008		768.....72960		698.....75007		
16	997.....67388		917.....69174		840.....71040		767.....72993		696.....75042		14
17	996.....67417		916.....69204		839.....71072		765.....73026		695.....75077		13
	995.....67447		914.....69235		838.....71104		764.....73060		694.....75112		
	993.....67476		913.....69265		836.....71135		763.....73093		693.....75147		
18	992.....67505		912.....69296		835.....71167		762.....73127		692.....75182		12
19	991.....67534		910.....69326		834.....71199		761.....73160		691.....75217		11
	989.....67563		909.....69357		833.....71231		759.....73193		690.....75252		
	988.....67593		908.....69387		831.....71263		758.....73227		688.....75287		
20	987.....67622		907.....69418		830.....71295		757.....73260		687.....75322		10
21	985.....67651		905.....69449		829.....71327		756.....73294		686.....75358		9
	984.....67681		904.....69479		828.....71359		755.....73328		685.....75393		
	982.....67710		903.....69510		826.....71391		753.....73361		684.....75428		
22	981.....67739		901.....69541		825.....71423		752.....73395		683.....75464		8
23	980.....67769		900.....69571		824.....71455		751.....73429		682.....75499		7
	978.....67798		899.....69602		823.....71488		750.....73462		680.....75534		
	977.....67828		897.....69633		821.....71520		749.....73496		679.....75570		
24	976.....67857		896.....69664		820.....71552		747.....73530		678.....75605		6
25	974.....67886		895.....69694		819.....71584		746.....73563		677.....75641		5
	973.....67916		894.....69725		818.....71616		745.....73597		676.....75676		
	972.....67945		892.....69756		816.....71649		744.....73631		675.....75712		
26	970.....67975		891.....69787		815.....71681		743.....73665		674.....75747		4
27	969.....68005		890.....69815		814.....71713		742.....73699		673.....75783		3
	968.....68034		888.....69849		813.....71746		740.....73733		672.....75819		
	966.....68064		887.....69879		811.....71778		739.....73767		670.....75854		
28	965.....68093		886.....69910		810.....71810		738.....73801		669.....75890		2
29	964.....68123		885.....69941		809.....71843		737.....73835		668.....75926		1
	962.....68153		883.....69972		808.....71875		736.....73869		667.....75961		
	961.....68182		882.....70003		807.....71908		735.....73903		666.....75997		
30	960.....68212		881.....70034		805.....71940		733.....73937		665.....76033		0
	A	B	A	B	A	B	A	B	A	B	
	102°00'		101°30'		101°00'		100°30'		100°00'		

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

	80°00'		80°30'		81°00'		81°30'		82°00'		
	A	B	A	B	A	B	A	B	A	B	
0	665.....76033		600.....78239		538.....80567		480.....83030		425.....85644		30
1	664.....76069		599.....78277		537.....80607		479.....83072		424.....85689		29
	663.....76105		598.....78315		536.....80647		478.....83114		423.....85734		
	661.....76141		597.....78352		535.....80687		477.....83157		422.....85779		
2	660.....76176		595.....78390		534.....80727		476.....83199		421.....85825		28
3	659.....76212		594.....78428		533.....80767		475.....83242		420.....85870		27
	658.....76248		593.....78466		532.....80807		474.....83284		419.....85915		
	657.....76284		592.....78504		531.....80847		473.....83327		418.....85960		
4	656.....76320		591.....78542		530.....80887		472.....83369		418.....86006		26
5	655.....76357		590.....78580		529.....80927		471.....83412		417.....86051		25
	654.....76393		589.....78618		528.....80967		470.....83455		416.....86096		
	653.....76429		588.....78656		527.....81008		469.....83497		415.....86142		
6	652.....76465		587.....78694		526.....81048		468.....83540		414.....86187		24
7	650.....76501		586.....78733		525.....81088		467.....83583		413.....86233		23
	649.....76537		585.....78771		524.....81129		467.....83626		412.....86278		
	648.....76574		584.....78809		523.....81169		466.....83668		411.....86324		
8	647.....76610		583.....78847		522.....81210		465.....83711		411.....86370		22
9	646.....76646		582.....78886		521.....81250		464.....83754		410.....86415		21
	645.....76683		581.....78924		520.....81291		463.....83797		409.....86461		
	644.....76719		580.....78962		519.....81331		462.....83840		408.....86507		
10	643.....76756		579.....79001		518.....81372		461.....83884		407.....86553		20
11	642.....76792		578.....79039		517.....81413		460.....83927		406.....86599		19
	641.....76828		577.....79078		516.....81453		459.....83970		405.....86645		
	639.....76865		576.....79116		515.....81494		458.....84013		405.....86691		
12	638.....76902		575.....79155		514.....81535		457.....84056		404.....86737		18
13	637.....76938		574.....79193		513.....81576		456.....84100		403.....86783		17
	636.....76975		573.....79232		512.....81617		455.....84143		402.....86829		
	635.....77011		571.....79271		511.....81657		454.....84186		401.....86876		
14	634.....77048		570.....79309		510.....81698		454.....84230		400.....86922		16
15	633.....77085		569.....79348		509.....81739		453.....84273		399.....86968		15
	632.....77122		568.....79387		508.....81780		452.....84317		399.....87015		
	631.....77158		567.....79426		507.....81821		451.....84361		398.....87061		
16	630.....77195		566.....79465		506.....81863		450.....84404		397.....87107		14
17	629.....77232		565.....79503		505.....81904		449.....84448		396.....87154		13
	627.....77269		564.....79542		504.....81945		448.....84492		395.....87201		
	626.....77306		563.....79581		504.....81986		447.....84535		394.....87247		
18	625.....77343		562.....79620		503.....82027		446.....84579		393.....87294		12
19	624.....77380		561.....79659		502.....82069		445.....84623		392.....87341		11
	623.....77417		560.....79698		501.....82110		444.....84667		392.....87387		
	622.....77454		559.....79737		500.....82151		444.....84711		391.....87434		
20	621.....77491		558.....79777		499.....82193		443.....84755		390.....87481		10
21	620.....77528		557.....79816		498.....82234		442.....84799		389.....87528		9
	619.....77565		556.....79855		497.....82276		441.....84843		388.....87575		
	618.....77602		555.....79894		496.....82317		440.....84887		387.....87622		
22	617.....77639		554.....79933		495.....82359		439.....84931		387.....87669		8
23	616.....77677		553.....79973		494.....82400		438.....84976		386.....87716		7
	615.....77714		552.....80012		493.....82442		437.....85020		385.....87764		
	614.....77751		551.....80051		492.....82484		436.....85064		384.....87811		
24	612.....77788		550.....80091		491.....82526		435.....85109		383.....87858		6
25	611.....77826		549.....80130		490.....82567		434.....85153		382.....87906		5
	610.....77863		548.....80170		489.....82609		434.....85197		381.....87953		
	609.....77901		547.....80209		488.....82651		433.....85242		381.....88001		
26	608.....77938		546.....80249		487.....82693		432.....85286		380.....88048		4
27	607.....77976		545.....80288		486.....82735		431.....85331		379.....88096		3
	606.....78013		544.....80328		485.....82777		430.....85376		378.....88143		
	605.....78051		543.....80368		484.....82819		429.....85420		377.....88191		
28	604.....78088		542.....80407		483.....82861		428.....85465		376.....88239		2
29	603.....78126		541.....80447		482.....82903		427.....85510		376.....88286		1
	602.....78164		540.....80487		482.....82945		426.....85555		375.....88334		
	601.....78201		539.....80527		481.....82987		426.....85599		374.....88382		
30	600.....78239		538.....80567		480.....83030		425.....85644		373.....88430		0
	A	B	A	B	A	B	A	B	A	B	
	99°30'		99°00'		98°30'		98°00'		97°30'		

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	82°30'		83°00'		83°30'		84°00'		84°30'		
	A	B	A	B	A	B	A	B	A	B	
0	373.....88430		325.....91411		280.....94614		238.6.....98076		200.4...101843		30
1	372.....88478		324.....91462		279.....94670		237.9.....98137		199.8...101908		29
	371.....88526		323.....91514		279.....94725		237.2.....98197		199.2...101974		
	371.....88574		323.....91565		278.....94781		236.6.....98257		198.6...102040		
2	370.....88623		322.....91617		277.....94836		235.9.....98318		198.0...102106		28
3	369.....88671		321.....91668		276.....94892		235.3.....98378		197.4...102172		27
	368.....88719		320.....91720		276.....94948		234.6.....98439		196.8...102238		
	367.....88767		319.....91772		275.....95004		233.9.....98499		196.2...102304		
4	366.....88816		319.....91824		274.....95060		233.3.....98560		195.6...102371		26
5	366.....88864		318.....91876		274.....95116		232.6.....98621		195.0...102437		25
	365.....88913		317.....91928		273.....95172		232.0.....98682		194.4...102504		
	364.....88961		316.....91980		272.....95228		231.3.....98743		193.8...102570		
6	363.....89010		316.....92032		271.....95285		230.7.....98804		193.2...102637		24
7	362.....89059		315.....92085		271.....95341		230.0.....98865		192.6...102704		23
	362.....89107		314.....92137		270.....95397		229.4.....98926		192.0...102771		
	361.....89156		313.....92189		269.....95454		228.7.....98988		191.4...102838		
8	360.....89205		313.....92242		269.....95510		228.1.....99049		190.8...102905		22
9	359.....89254		312.....92294		268.....95567		227.4.....99111		190.2...102973		21
	358.....89303		311.....92347		267.....95624		226.8.....99172		189.6...103040		
	357.....89352		310.....92399		267.....95681		226.1.....99234		189.0...103107		
10	357.....89401		310.....92452		266.....95737		225.5.....99296		188.4...103175		20
11	356.....89450		309.....92505		265.....95795		224.8.....99357		187.8...103243		19
	355.....89499		308.....92558		264.....95851		224.2.....99419		187.2...103311		
	354.....89548		307.....92610		264.....95909		223.5.....99482		186.7...103379		
12	353.....89597		307.....92663		263.....95966		222.9.....99544		186.1...103447		18
13	353.....89647		306.....92716		262.....96023		222.3.....99606		185.5...103515		17
	352.....89696		305.....92769		262.....96080		221.6.....99668		184.9...103583		
	351.....89746		304.....92823		261.....96138		221.0.....99731		184.3...103651		
14	350.....89795		304.....92876		260.....96195		220.3.....99793		183.7...103720		16
15	349.....89845		303.....92929		260.....96253		219.7.....99856		183.2...103788		15
	349.....89894		302.....92982		259.....96310		219.1.....99918		182.6...103857		
	348.....89944		301.....93036		258.....96368		218.4.....99981		182.0...103926		
16	347.....89994		301.....93089		257.....96426		217.8...100044		181.4...103995		14
17	346.....90044		300.....93143		257.....96484		217.2...100107		180.8...104064		13
	345.....90093		299.....93196		256.....96542		216.5...100170		180.3...104133		
	345.....90143		298.....93250		255.....96600		215.9...100233		179.7...104202		
18	344.....90193		298.....93304		255.....96658		215.3...100296		179.1...104272		12
19	343.....90243		297.....93358		254.....96716		214.6...100360		178.5...104341		11
	342.....90293		296.....93411		253.....96774		214.0...100423		178.0...104411		
	341.....90344		295.....93465		253.....96833		213.4...100487		177.4...104480		
20	341.....90394		295.....93519		252.....96891		212.8...100550		176.8...104550		10
21	340.....90444		294.....93573		251.....96950		212.1...100614		176.2...104620		9
	339.....90494		293.....93628		251.....97008		211.5...100678		175.7...104690		
	338.....90545		292.....93682		250.....97067		210.9...100742		175.1...104760		
22	337.....90595		292.....93736		249.....97126		210.3...100806		174.5...104830		8
23	337.....90646		291.....93790		249.....97184		209.6...100870		174.0...104901		7
	336.....90696		290.....93845		248.....97243		209.0...100943		173.4...104971		
	335.....90747		289.....93899		247.....97302		208.4...100998		172.8...105042		
24	334.....90798		289.....93954		247.....97361		207.8...101063		172.3...105113		6
25	333.....90848		288.....94009		246.....97420		207.1...101127		171.7...105183		5
	333.....90899		287.....94063		245.....97480		206.5...101192		171.1...105254		
	332.....90950		287.....94118		245.....97539		205.9...101256		170.6...105325		
26	331.....91001		286.....94173		244.....97598		205.3...101321		170.0...105397		4
27	330.....91052		285.....94228		243.....97658		204.7...101386		169.5...105468		3
	330.....91103		284.....94283		243.....97717		204.1...101451		168.9...105539		
	329.....91154		284.....94338		242.....97777		203.5...101516		168.4...105611		
28	328.....91205		283.....94393		241.....97837		202.8...101581		167.8...105683		2
29	327.....91257		282.....94448		241.....97897		202.2...101646		167.2...105754		1
	326.....91308		281.....94503		240.....97957		201.6...101712		166.7...105826		
	326.....91359		281.....94559		239.....98017		201.0...101777		166.0...105898		
30	325.....91411		280.....94614		239.....98076		200.4...101843		165.6...105970		0
	A	B	A	B	A	B	A	B	A	B	
	97°00'		96°30'		96°00'		95°30'		95°00'		

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE											
	85°00'		85°30'		86°00'		86°30'		87°00'		
	A	B	A	B	A	B	A	B	A	B	
0	165.6...105970		134.1...110536		105.9...115641		81.1...121432		59.6...128120		30
1	165.0...106043		133.6...110616		105.5...115732		80.7...121538		59.2...128241		29
	164.5...106115		133.1...110696		105.0...115823		80.3...121639		58.9...128362		
	163.9...106187		132.6...110777		104.6...115913		79.9...121743		58.6...128483		
2	163.4...106260		132.1...110858		104.2...116004		79.5...121848		58.2...128605		28
3	162.8...106333		131.6...110939		103.7...116096		79.2...121952		57.9...128727		27
	162.3...106406		131.1...111020		103.3...116187		78.8...122057		57.6...128849		
	161.7...106479		130.6...111101		102.9...116278		78.4...122161		57.3...128972		
4	161.2...106552		130.1...111183		102.4...116370		78.0...122267		56.9...129095		26
5	160.6...106625		129.6...111264		102.0...116462		77.6...122372		56.6...129218		25
	160.1...106698		129.2...111346		101.6...116554		77.3...122478		56.3...129342		
	159.6...106772		128.7...111428		101.1...116647		76.9...122584		56.0...129466		
6	159.0...106846		128.2...111510		100.7...116739		76.5...122690		55.7...129591		24
7	158.5...106919		127.7...111592		100.3...116832		76.1...122796		55.3...129716		23
	157.9...106993		127.2...111674		99.8...116925		75.8...122903		55.0...129841		
	157.4...107067		126.7...111757		99.4...117018		75.4...123010		54.7...129967		
8	156.9...107141		126.2...111839		99.0...117112		75.0...123117		54.4...130093		22
9	156.3...107216		125.8...111922		98.5...117205		74.6...123225		54.1...130219		21
	155.8...107290		125.3...112005		98.1...117299		74.3...123332		53.7...130346		
	155.2...107364		124.8...112088		97.7...117393		73.9...123441		53.4...130473		
10	154.7...107439		124.3...112171		97.3...117487		73.5...123549		53.1...130600		20
11	154.2...107514		123.8...112255		96.8...117581		73.2...123657		52.8...130728		19
	153.6...107589		123.4...112338		96.4...117676		72.8...123766		52.5...130856		
	153.1...107664		122.9...112422		96.0...117771		72.4...123875		52.2...130985		
12	152.6...107739		122.4...112506		95.6...117866		72.1...123985		51.9...131114		18
13	152.1...107814		121.9...112590		95.2...117961		71.7...124095		51.6...131243		17
	151.5...107890		121.5...112674		94.7...118056		71.3...124204		51.3...131373		
	151.0...107965		121.0...112759		94.3...118152		71.0...124315		51.0...131503		
14	150.5...108041		120.5...112843		93.9...118248		70.6...124425		50.7...131633		16
15	149.9...108117		120.1...112928		93.5...118344		70.3...124536		50.3...131764		15
	149.4...108193		119.6...113013		93.1...118440		69.9...124647		50.0...131896		
	148.9...108269		119.1...113098		92.7...118537		69.5...124759		49.7...132027		
16	148.4...108345		118.7...113183		92.3...118633		69.2...124870		49.4...132159		14
17	147.8...108421		118.2...113269		91.8...118730		68.8...124982		49.1...132292		13
	147.3...108498		117.7...113354		91.4...118827		68.5...125094		48.8...132425		
	146.8...108574		117.3...113440		91.0...118925		68.1...125207		48.5...132558		
18	146.3...108651		116.8...113526		90.6...119022		67.8...125320		48.2...132692		12
19	145.8...108728		116.3...113612		90.2...119120		67.4...125433		47.9...132826		11
	145.2...108805		115.9...113699		89.8...119218		67.1...125546		47.6...132961		
	144.7...108882		115.4...113785		89.4...119316		66.7...125660		47.3...133096		
20	144.2...108960		114.9...113872		89.0...119415		66.4...125774		47.1...133231		10
21	143.7...109037		114.5...113958		88.6...119513		66.0...125888		46.8...133367		9
	143.2...109115		114.0...114045		88.2...119612		65.7...126003		46.5...133503		
	142.7...109192		113.6...114133		87.8...119711		65.3...126118		46.2...133640		
22	142.2...109270		113.1...114220		87.4...119811		65.0...126233		45.9...133777		8
23	141.6...109348		112.7...114307		87.0...119910		64.6...126349		45.6...133914		7
	141.1...109426		112.2...114395		86.6...120010		64.3...126465		45.3...134052		
	140.6...109505		111.7...114483		86.2...120110		63.9...126581		45.0...134191		
24	140.1...109583		111.3...114571		85.8...120211		63.6...126697		44.7...134330		6
25	139.6...109662		110.8...114659		85.4...120311		63.3...126814		44.4...134469		5
	139.1...109740		110.4...114747		85.0...120412		62.9...126931		44.2...134609		
	138.6...109819		109.9...114836		84.6...120513		62.6...127049		43.9...134749		
26	138.1...109898		109.5...114925		84.2...120614		62.2...127166		43.6...134890		4
27	137.6...109978		109.0...115014		83.8...120715		61.9...127284		43.3...135031		3
	137.1...110057		108.6...115103		83.4...120817		61.6...127403		43.0...135173		
	136.6...110136		108.1...115192		83.0...120919		61.2...127521		42.7...135315		
28	136.1...110216		107.7...115282		82.6...121021		60.9...127640		42.5...135457		2
29	135.6...110296		107.3...115371		82.2...121124		60.6...127760		42.2...135600		1
	135.1...110375		106.8...115461		81.9...121226		60.2...127880		41.9...135744		
	134.6...110455		106.4...115551		81.5...121329		59.9...128000		41.6...135888		
30	134.1...110536		105.9...115641		81.1...121432		59.6...128120		41.4...136032		0
	A	B	A	B	A	B	A	B	A	B	
	94°30'		94°00'		93°30'		93°00'		92°30'		

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	87°30'		88°00'		88°30'		89°00'		89°30'		
	A	B	A	B	A	B	A	B	A	B	
0	41.4...136032		26.5...145718		14.9...158208		6.6...175814		1.7...205916		30
1	41.1...136177		26.2...145899		14.7...158450		6.5...176178		1.6...206646		29
	40.8...136322		26.0...146081		14.6...158693		6.4...176544		1.5...207388		
	40.5...136468		25.8...146264		14.4...158938		6.3...176914		1.5...208143		
2	40.3...136615		25.6...146448		14.2...159184		6.2...177287		1.4...208912		28
3	40.0...136761		25.4...146632		14.1...159431		6.1...177663		1.4...209695		27
	39.7...136909		25.2...146817		13.9...159680		6.0...178042		1.3...210491		
	39.4...137057		24.9...147003		13.7...159930		5.9...178424		1.3...211303		
4	39.2...137205		24.7...147190		13.6...160182		5.8...178810		1.2...212130		26
5	38.9...137354		24.5...147377		13.4...160435		5.7...179200		1.2...212974		25
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	A	B	A	B	A	B	A	B	A	B	
	92°00'		91°30'		91°00'		90°30'		90°00'		

GLOSSARY

a'	prime (used to indicate a variable under different situations)
ACR	armored cavalry regiment
AM	amplitude modulated
approx	approximately
ARDF	airborne radio direction finding
b''	double prime (continuation of the variable)
bearing	The angular measurement in degrees from north (true, magnetic, or grid) of an arriving radio wave with relation to the DF site.
BM	bearing mean
BO	bearing observed
BPE	best point estimate
BT	bearing true
c	certain
CADF	commutated-antenna direction finder
CCR	corrected compass rose
CDAA	circularly disposed antenna array
CEP	circular error probability
C&J	collection and jamming
c o	company
Col	column
COMSEC	communications security
Cos	cosecants/cosine
cot	cotangent
CRT	cathode ray tube
cut	The point of intersection of two DF lines of bearing.
CW	continuous wave
D	doubtful
DA	Department of the Army
DF	direction finding
diff	difference
div	division
DWDF	direct wave direction finding
E	east
E field	electrical field
EAC	echelons above corps
EEP	elliptical error probability
EF	SSL term
EHF	extremely high frequency
EL	The elevation angle of arriving signal measured from the horizontal plane of the earth.
EM	electromagnetic
EW	electronic warfare

FE	SSL term
FEF	SSL term
fix	The most probable location of a target transmitter's antenna when three or more DF lines of bearing have been plotted on a chart or map.
flash	A high priority message from NCS to the DF sites. The message, usually sent on a restricted radio circuit, provides the basic target information and requested DF support.
FLOT	forward line of own troops
F M	field manual; frequency modulated
FORTAN	formula translation
freq	frequency
GCAD	great circle azimuth and distance
G H z	gigahertz
GN	grid north
GPS	global positioning system
h	height
h'	Virtual height of the ionospheric layer (where the target signal is reflected) from the surface of the earth. (H prime)
H field	magnetic field
HF	high frequency
Hz	hertz
IEWSE	intelligence and electronic warfare support element
INSCOM	United States Army Intelligence and Security Command
I R	information requirements
kHz	kilohertz
km	kilometer(s)
L or LAT	latitude
LCSS	lightweight camouflage screen system
LF	low frequency
LOB	line of bearing(s)
log	logarithm
long	longitude
LOP	line of position
LOS	line of sight
maint	maintenance
MBG	mean bearing grouping
METT-T	mission, enemy, terrain, troops and time available
MF	medium frequency
MHz	megahertz
MI	military intelligence
minute	A subdivision of angular measure. One degree equals sixty minutes.
MOS	military occupational specialty
MRDFS	man-transportable radio direct ion finding system

N	north seeking; north
NADF	narrow aperture direction finding
NCS	net control station
Nm	nautical miles
NSA	National Security Agency
NSACSS	National Security Agency/Central Security Service
OB	order of battle
OIS	oblique incidence sounder
op	operator
PIR	priority intelligence requirements
plot	The placing of DF bearings on a chart or map so that a target's location can be determined by reference to grid or geographic coordinates. Also called plotting.
POL	petroleum, oils and lubricants
QUMP	quasi uni-modal propagation
RDF	radio direction finding
RF	radio frequency; radiated frequency
s	south
S3	Operations and Training Officer (US Army)
SD	standard deviation
SE	systematic error
SF	Special Forces
SHF	super high frequency
SIGINT	signals intelligence
sin	sine
Sm	statute miles
SOP	standing operating procedures
SSB	single side band
SSL	single station locator
STP	soldier training publication
SWDF	sky wave direction finding
TA	traffic analysis
tan	tangent
TC	training circular
TCAE	technical control and analysis element
TDDF	time-difference direction finders
TEC	Training Extension Course
tip-off	A message, usually initiated by an intercept position, requesting DF action on selected transmitter(s). A tip-off will include, as a minimum, the target activity and frequency and any identifying call signs.
TM	technical manual
TN	true north
TOC	tactical operations center

TO&E	table of organization and equipment
tracking	Real-time identification of the target activity to ensure that the DF sites acquire the correct target. Tracking is usually performed by the NCS on the flash circuit.
TRADOC	United States Army Training and Doctrine Command
UHF	ultra high frequency
us	United States
USA	United States of America
USAISD	United States Army Intelligence School, Fort Devens
USSID	United States Signals Intelligence Directive
UTM	universal transverse mercator
VHF	very high frequency
VIS	vertical incidence sounder
VLF	very low frequency
W	west
WADF	wide aperture direction finding
WFA	wavefront analysis
WFT	wavefront testing
WWII	World War II
$\angle$	angle (geometric symbol)
$^{\circ}$	degrees (1 degree equals 60 minutes)
$'$	minutes (1 minute equals 60 seconds)
$''$	seconds
Σ	summation operator for calculus
σ	variance

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